ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 90, Feb. 23. 5734

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See Advertisement page 56. 5707

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See half-page Advertisement, last and next week.

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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES. } Royle's Patents
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See Full Page Advt. page 68, Feb. 9.

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MONOMETER MANUFACTURING CO., LTD.,
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See Advertisement page 88, Feb. 16.

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See Advertisement page 26, Feb. 16. 5402

Gas Engines, Suction Plants,
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Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
5460
See half-page Advertisement page 73, Feb. 23.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir W. FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5864

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SALE OF DESIGNS FOR LIGHT RAILWAY MATERIAL.

Notice is Hereby Given that the final date for the reception of Offers for the DESIGNS advertised for Sale in the advertisement appearing in the issue of this paper of the 2nd February, 1917, has been EXTENDED to TUESDAY, 10th April, 1917, the other conditions remaining as originally advertised.
F. H. RUSSELL, Receiver.
Address of the Receiver's Cairo Office:—"Gresham House," Sharia Suliman Pasha, Cairo.
Address of the Receiver's London Office:—"Palmerston House," Old Broad Street, London, E.C. G 256

TENDERS.

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive **Tenders for the Supply of the** following STORES, namely:—
ZINC SHEETS, &c.
STATIONERY, &c.
PAINTS, DRYSALTERIES, &c.
MANTLES FOR LAMPS.
Specifications and Forms of Tender may be obtained at this Office on payment of the Fee for the Specification, which payment will not be returned.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Zinc Sheets, &c.," or as the case may be, not later than Eleven o'clock, a.m., on Thursday, the 8th March, 1917.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE,
Company's Offices, Secretary.
48, Copthall Avenue, London, E.C.
23th February, 1917. G 291

IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

The PUBLIC TRUSTEE invites **Tenders for the Purchase of** the Whole or any part of 119,660 Shares of £5 each, fully paid, in SIEMENS BROTHERS & COMPANY, LIMITED, vested in him as Custodian by an Order made by the Board of Trade, in pursuance of Section 4 of the Trading with the Enemy Amendment Act, 1916, and dated 9th August, 1916.
The issued capital of the Company consists of 120,000 Shares of £5 each, fully paid.
The purchasers, who must be British-born subjects, will be required to make a sworn Declaration as to nationality and freedom from foreign control on a form to be obtained from the Offices of the Public Trustee.
The purchasers will also be required to satisfy the Public Trustee as to their financial and technical ability to carry on the business of the Company as efficiently as heretofore, or otherwise to the satisfaction of the Government.
A report upon the Company's operations and affairs has been prepared by the Company, in conjunction with the Company's Auditors (Messrs. PRICE, WATERHOUSE & Co.), and Messrs. TURQUAND, YOUNGS & Co. Copies of this report can be obtained, subject as hereinafter mentioned, together with copies of Company's accounts up to the 31st December, 1916, at the Offices of the Public Trustee, Kingsway, W.C. All applicants will be required to satisfy the Public Trustee as to any matter which he may think fit to investigate before copies of said report or accounts will be supplied.
Intending Tenderers who desire to inspect the property of the Company, should apply to the Public Trustee for an authority to do so.
Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Monday, the 2nd day of April, 1917, at Twelve o'clock Noon, and marked on the envelope, "Tender, Siemens Shares."
The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith.
Forms of Tender can be obtained from the PUBLIC TRUSTEE.
Dated this 8th day of February, 1917. G 160
C. J. STEWART, Public Trustee,
Custodian for England and Wales.

APPOINTMENTS OPEN.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will, in 1917,

Appoint a Few Natives of India as ASSISTANT ENGINEERS in the Indian Public Works and State Railway Departments.
Candidates must be British subjects, and, save as provided in Appendix III to the Regulations, must be not less than 21 and not more than 24 years of age on the 1st July, 1917. They must have either obtained one of certain recognised University degrees or other distinctions in Engineering, or have passed the Associate Membership Examination of the Institution of Civil Engineers.
Applications must reach the India Office by 31st March, 1917. Printed Forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, London, S.W.
India Office, London.
December, 1916. F 621

Wanted, Assistant Works MANAGERS for large Aeroplane Works, London District. Good opening for men with experience in engineering shop management. Commencing salary, £300 per annum.—Address, G 163, Offices of ENGINEERING.

PLYMOUTH EDUCATION AUTHORITY.

DAY JUNIOR TECHNICAL SCHOOL.

Applications are Invited for the APPOINTMENT of an ASSISTANT MASTER (ineligible for Military Service), with qualifications in Engineering and experience in Class Teaching. Must be prepared to interest himself in school games. Salary scale, £100 per annum, by £10 yearly to £180. Experience elsewhere may be taken into account in fixing initial salary. Forms of application, returnable not later than March 17th, can be obtained at the Education Office, Cobourg Street, Plymouth.
R. CHANDLER COOK,
Education Secretary. G 259

Superintendent of "Stores" WANTED, for a National Factory in South Yorkshire, must be experienced in stores bookkeeping and stores organisation. Competent to control men.
Applicants employed on War work will only be considered with the sanction of their present employers. Must be ineligible for the army.—Address, stating age, experience, and salary required, to G 195, Offices of ENGINEERING.

Works Superintendent or ASSISTANT WORKS MANAGER REQUIRED by large well-known firm, Government controlled, making large and small engines, repetition and general work. Applications will only be considered from experienced engineers thoroughly conversant with latest manufacturing methods and who have made good in every way in similar position in large works. Permanent position to right man. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and G 244.

First-class Experienced ESTIMATOR WANTED by Government controlled works making large and small engines, repetition and general work; man with thorough practical knowledge of machining and fitting, &c., who could control rate-fixing, progress, and demonstration. Only men thoroughly experienced need apply. Permanent position to suitable man. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and G 245.

Male Clerk (Ineligible) REQUIRED for Planning Department in large Engineering Works, Manchester district. Must have had good education, experience in engineering, and used to keeping stock figures. Preference given to discharged soldier. No man employed on Government work need apply.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 242.

Large Engineering Firm, Government controlled, REQUIRE the SERVICES of thoroughly experienced WORKS ENGINEER used to lay-out, erection, and complete equipment of up-to-date works; well versed in modern machining and manufacturing methods and the upkeep of plant for maximum output. Permanency to good man. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and G 242.

Electrical Engineer Required to take full control of all electrical installations and upkeep in large Government controlled works (bulk of current from Corporation). Applications will only be considered from experienced men who have held similar positions with good records. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and G 247.

Steel Foundry.—Wanted, practical WORKS MANAGER, to superintend construction of either Siemens open-hearth furnaces or stock converter plant, and afterwards to take charge. Applicants employed on War work will only be considered with the sanction of their present employers.—Apply, stating particulars of experience, age, present employment, and salary expected, "FOUNDRY," WILLIAM POTTRUS & Co., Advertising Agents, Glasgow. G 269

Chief Rate Fixer Required by one of the largest firms in the Midlands manufacturing Internal Combustion Engines and Motor Cars. Must be capable of laying out processes and fixing rates to drawings; good organiser; take entire charge department. Only highly experienced men of strong character and possessed of considerable tact need apply. Generous salary to right man. No application from men already engaged on Government work will be considered.—Send full particulars to your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 2958. G 214

Rate Fixer for Bench Filing and fitting, N.W. London. Good prospects for a live man with experience.—Apply, in writing, giving full details of past experience and wages required to G 253, Offices of ENGINEERING. No person residing more than ten miles away or already engaged on Government work need apply.

Works Manager Wanted, to take Full Charge of Plant in Scotland engaged in making large quantities of repetition work to accurate dimensions. Applicants are desired to give fullest particulars of past experience which will be treated in strictest confidence. It is essential that applicants state age and salary required.—Apply, in first instance, to "REPETITION," WILLIAM POTTRUS & Co., Advertising Agents, Glasgow. G 270

Engineer, with Shop, D.O., and Technical Experience, as CHIEF ASSISTANT to Head Inspector in a large Engineering Works in the Manchester district. Experience of small repetition work desirable. Preference given to discharged officer or N.C.O. Good salary and prospects. No man engaged on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 240.

Resident Engineer.—Wanted by an Engineering Firm in Lincolnshire a fully-qualified Electrical and Mechanical ENGINEER, with experience in steam engines, gas engines, and steam turbines A.C. and D.C. currents, to take charge of and run Power Station with fullest possible efficiency and economy. No man in Government work or eligible for the Army will be considered.—Apply, in writing, with full particulars of experience and salary required, to HAL WILLIAMS & COMPANY, 3, Salter's Hall Court, London, E.C. G 264

Engineer, with Works and Technical Experience, REQUIRED immediately as Chaser in Planning Department in large Engineering Works engaged in manufacturing large quantities of small parts. Good salary and prospects to live man. No man employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 241.

Wanted, a Foundry Works MANAGER, with full knowledge of machine moulding and capable of installing a machine moulding plant, must be a thoroughly competent man and used to this class of work.—Address, G 257, Offices of ENGINEERING.

Storekeeper, to Take Charge of raw material and tools in aeroplane works, N.W. London.—Apply, G 254, Offices of ENGINEERING. No person residing more than ten miles away nor already engaged on Government work need apply.

Chief Draughtsman Wanted, for large Aeroplane Works, London district. Good salary to experienced applicant. No person resident more than ten miles away nor already engaged on Government work will be engaged.—Address, G 237, Offices of ENGINEERING.

Wanted, Two First-class Jig AND TOOL DRAUGHTSMEN, used to fixing operations and limits. Also two Junior DRAUGHTSMEN. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A2977. G 238

First-class Draughtsman WANTED, for large marine engineering establishment as first assistant in estimating office. State experience, age, and salary expected. No one already on Government work need apply.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 2974. G 208

Wanted, Draughtsmen for Jig, Tool, and General Design Work on Aeroplane Engines. Men used to motor car or high-class small engineering work preferred. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 2982. G 275

Draughtsman, Mechanical, Wanted, to take leading position in Drawing Office in new Company in Midlands engaged upon urgent War Work. Excellent prospects for a young energetic man. One with some experience in jig and tool design and automobile construction preferred. No man on Government work can be engaged without consent of present employers. Applications in the first instance should be made to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this paper & No. A 2773. F 982

Wanted, Ship Draughtsman to make calculations of strengths of the structure of warships. Applicants must apply to their nearest EMPLOYMENT EXCHANGE, mentioning ENGINEERING and No. G 206, and stating age, experience, and salary required.
No person already employed on Government work will be engaged. G 206

Wanted, for Iron and Steel Works in Lincolnshire, several first-class DRAUGHTSMEN, experienced in the lay-out and design of steel works plant, rolling mills, hydraulic machinery and general all round work. No one already on Government work need apply.—Reply, stating age, experience, when at liberty and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 2943. G 216

Required, the Services of Four Skilled DRAUGHTSMEN, accustomed to either Blast Furnaces or Steelworks constructional design. Good salary offered to suitable men. Applicants should state age, experience, salary required, and when at liberty. No one engaged at present on Government work need apply.—Apply, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2730. G 122

Wanted, Draughtsman for Controlled Establishment. One with knowledge of grinding and seed crushing plant preferred but not essential. No one already engaged on Government work need apply.—Apply, stating full particulars and salary required, to your nearest LABOUR EXCHANGE, mentioning this Journal and F 985.

Draughtsman, Experienced, REQUIRED with knowledge of Rolling Mills preferred, but one with mechanical experience would be considered. No person already engaged on Government work will be engaged.—Write or apply nearest EMPLOYMENT EXCHANGE, mentioning this Paper and G 265.

Draughtsman Wanted for a National Factory in South Yorkshire. Must be experienced and well qualified.
Applicants already employed on Government work will not be engaged. Must be ineligible for the Army.—Address, stating age, experience, and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 276.

Two Good Jig and Tool DRAUGHTSMEN REQUIRED for aeroplane work, used to zero or high-class car work. Give full particulars of previous experience, age and wages required. No person already engaged on Government work need apply.
Apply, your nearest EMPLOYMENT EXCHANGE, quoting No. A 2967. G 252

Reinforced Concrete DRAUGHTSMAN REQUIRED for temporary staff. Thorough knowledge of design and details of reinforced concrete buildings, dock walls, quays, piles, &c., essential. No one engaged on Government work or eligible for military service need apply.—Applications stating age, experience, and salary required with copies of three recent testimonials to be addressed to the CHIEF ENGINEER, Port of London Authority, 109, Leadenhall Street, E.C. G 283

Required, at Once, Two or THREE competent JIG and TOOL DRAUGHTSMEN. None but fully qualified men need apply. No one on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 243.

Several Good Mechanical DRAUGHTSMEN REQUIRED, for Admiralty establishment. Accustomed to small high class work preferred. Salary according to ability.—State experience, age, and present position, to BOX 1001, care of Messrs. R. F. WHITE & SON, Genl. Advtg. Agents, 33, Fleet Street, E.C. G 268

Junior Draughtsman Wanted. —Apply by letter, with copies of testimonials, stating age, experience, and salary required, to S., care of HAY, FIELDING & Co., 43, Old Queen Street, Westminster, S.W. G 262

Wanted, a Machine Shop FOREMAN in Government Controlled Establishment in Midlands, engaged on locomotive and general engineering work. Applicants should possess a good all-round knowledge of machine shop practice, piecework, and be capable of controlling 60 men. Permanent and good salary to first-class man.—Apply, your nearest LABOUR EXCHANGE, mentioning No. A 2972. G 239

Wanted, Foreman Engineer for large Controlled Factory in East London. Must be used to handling men. Experienced in steam plant, pumps and machine tools. No one already on Government work will be engaged. Must be ineligible. Preference, if suitable, if discharged from either service. Permanent job for right man.—Address, giving full particulars, age, experience and pay to S. W. L., care of STREETS, 30, Cornhill, E.C. G 209

Wanted, Foreman Miller, also SETTER-UP for Browne & Sharpe, Cincinnati, Garvin, Becker, and Ingersoll machines in Government controlled establishment in southern county. No one resident more than 10 miles away or already employed on Government work will be engaged.—Applications, giving full details of experience and salary required, to G 276, Offices of ENGINEERING.

Wanted, Foreman Black- SMITH for Government controlled establishment in southern county. Must be able to undertake case hardening, &c. No one resident more than 10 miles away or already employed on Government work will be engaged.—Applications, giving full details of experience and salary required, to G 277, Offices of ENGINEERING.

A Large Firm of Engineers, in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4390, Offices of ENGINEERING.

SITUATIONS WANTED.

Shipyard Manager Wishes ENGAGEMENT. 25 years' experience drawing office and yard. Admiralty and merchant vessels of every type; new work and repairs. Disengaged at present.—Address, G 236, Offices of ENGINEERING.

Buying Manager to Manu- facturing electrical or mechanical engineers, who has specialized in the purchasing of engineering supplies, is OPEN to an ENGAGEMENT.
Experience has been with large engineering undertakings. Good technical knowledge of materials. Wide acquaintance with the markets for the supply of raw and finished materials, finished components, machine tools and all general stores. Would undertake the reorganization and systematising of purchasing department.—Address, G 118, Offices of ENGINEERING.

Well-Qualified Man, holding responsible position, DESIRES to NEGOTIATE with well-established manufacturing concern with view to position as General Manager; 26 years' experience shop practice, prime costs, organizing and commercial work with well-known English firm.—Address, G 176, Offices of ENGINEERING.

Metallurgist Seeks Engage- MENT. Honours Royal School of Mines. Special foundry knowledge; steel manufacture and high-class castings, all tests.—Address, G 285, Offices of ENGINEERING.

Shipping.—Advertiser (Chief Ship Draughtsman, 5 year's) DESIRES POSITION as Assistant, either in shipbuilding, ship repairing, or shipping company. Good training; first class references. Age 25 years.—Address, G 212, Offices of ENGINEERING.

Experienced Marine and General Engineer, ex-chief draughtsman and works manager, is OPEN to ENGAGEMENT during war. (Ineligible).—G 231, Offices of ENGINEERING.

Mechanical Engineer, with electrical experience, educated, experienced chief draughtsman, designer, and erector, heaviest steam turbine practice, electric power stations, REQUIRES responsible staff APPOINTMENT, highest credentials, ineligible.—Address, G 174, Offices of ENGINEERING.

Situation Wanted as Assistant Works Manager or Superintendent; 30 years' experience erection of steel work, engines, machinery, &c.—Address, G 247, Offices of ENGINEERING.

THE ARRANGEMENT OF MACHINE SHOPS.—No. XI.

By JOSEPH HORNER.

THE load which a ball bearing can carry depends to a great extent on the quality of both material and workmanship. It is, therefore, safe to say, the better the material the greater the carrying capacity of the bearing. The steel of which Skefko (S.K.F.) ball bearings are made originates from the Central Swedish Mines, and is charcoal-smelted, large number of balls, and as the load is automatically and equally divided between both rows of balls the most favourable working conditions are obtained.

It will be noted from the foregoing that the inner race is free to rotate at any angle within the spherical outer race without subjecting the bearing to any undue strain, providing therefore an automatic compensation for any springing or deflection of the shaft. As the plane of rotation of each series of balls is a cone, there is some resistance to axial thrust, which is not the case with a single row of adopted to prevent endlong movement of the bearing. It is maintained in position by a ring washer screwed on the shaft behind the bearing. If the bearing comes at the end of a shaft, a collar, tightened up with a nut, may grip the bearing against the shoulder. When, as so often happens, there are no shoulders on the shaft, as in the case of line shafting, split, taper, adapter sleeves are used, as in Fig. 91. In this case the inner race must be ground taper. The sleeve is drawn tightly, and held securely with a screwed ring run over a screwed

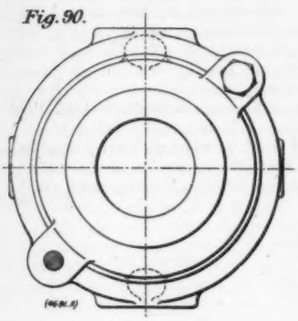


Fig. 90.

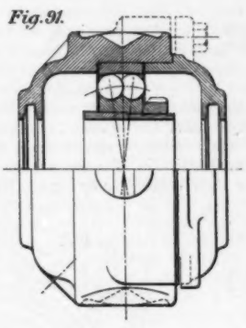


Fig. 91.

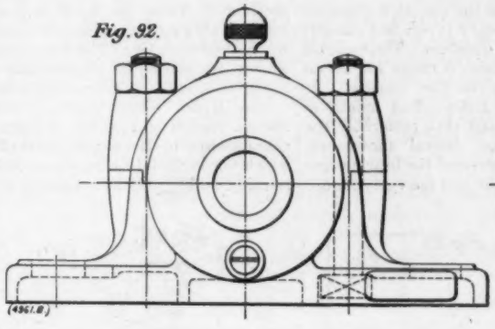


Fig. 92.

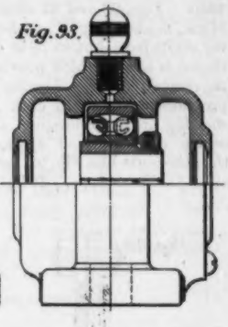


Fig. 93.

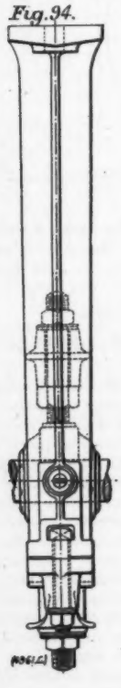


Fig. 94.

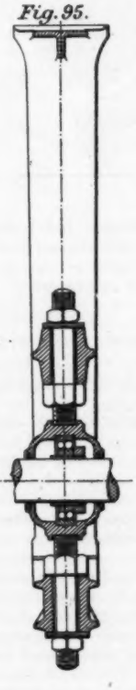


Fig. 95.

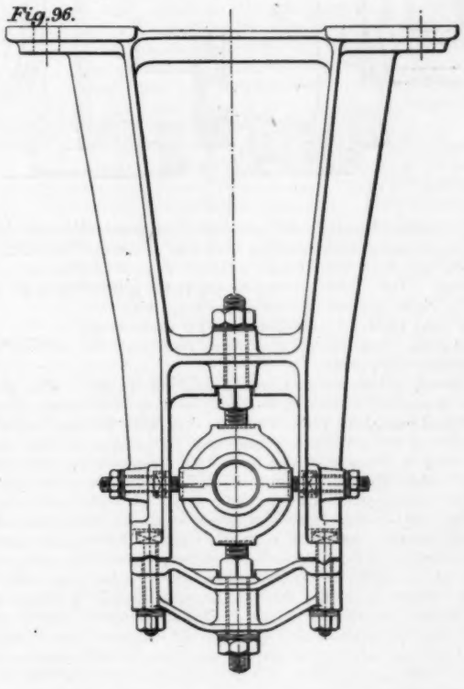


Fig. 96.

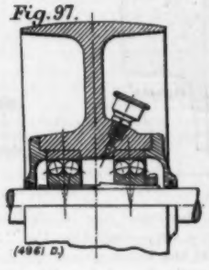


Fig. 97.

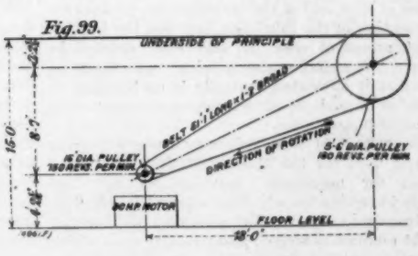


Fig. 99.

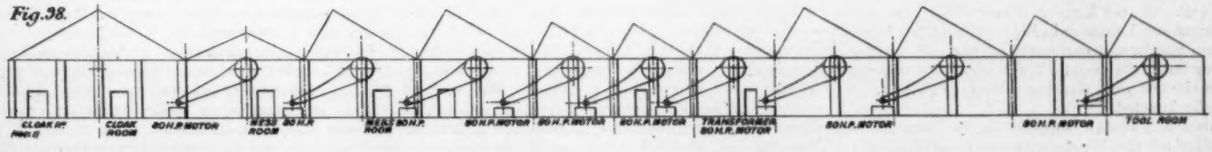


Fig. 98.

ensuring absolute freedom from impurities. The main feature of the construction, Figs. 90 and 91, is the double row of balls carried on opposite sides of a pressed steel cage and staggered, one ball being opposite the space between two balls on the side opposite. The balls run in parallel grooves in the inner race, and against a concave raceway in the outer race, the radius of which is struck from the centre of the shaft.

From this design several valuable results follow, which may be briefly stated. The bearing is self-aligning, because the balls roll on the surface of the spherically ground outer race. This movement is facilitated by the distribution of the load over a balls designed for radial pressures. This does not imply that they fulfil the function of thrust bearings, but that they are self-accommodating to slight lateral movements in shafting. Although, as already stated, the Skefko double-row self-aligning bearings are primarily intended for use as radial bearings, there are many instances on record where they are used as thrust bearings, particularly in high-speed woodworking machinery.

These bearings are sometimes fitted with the inner race a light tapping fit on the shaft, and driven on with blows delivered on the inner race with a piece of wood intervening, or with a piece of copper tube. The abutment of a shoulder on the shaft is extension of the sleeve. A compression screw prevents the screwed ring from slacking back. With the exception of a few special mountings the outer race of the bearing should be a suction or piston fit in its housing. This enables the outer race to creep very slowly, ensuring equal fatigue over the whole of the circumference, and also movement in a lateral direction.

These bearings of the adapter type are used in plummer blocks and hangers for line and counter-shafts. They are manufactured in two types, the standard and the heavy types. For line-shafting duty only one bearing on each separate and independent length of shaft is fixed in its housing,

taking the place of thrust collars. The others are free to slide laterally in either direction to allow for variations in length consequent on the effects of temperature. Loose pulleys have two bearings, one of the adapter type, the other ground parallel in the bore, mounted upon an extended sleeve which is made specially to suit the width of the pulley. The pulley hub forms a capacious reservoir for the lubricant and precludes any possible risk of overheating.

The illustrations on page 191 show various methods of mounting the Skefko ball bearings in shaft fittings. Figs. 92 and 93 show the standard plummer block, made in light and heavy types, and suitable for shafts from ¾ in. to 7½ in. diameter. The example shown is one in which provision is made for lateral movement of the bearing in the housing. As previously stated, in each independent length of shafting only one bearing, and that preferably the centre one, is fixed against lateral movement, the others are like Fig. 93, provided the bearings are all of the same type. If light and heavy types are to be mounted on the same line of shafting, the lightest-loaded heavy type should be the "fixed" bearing. In Fig. 93 the inner race is fixed on the shaft with an adapter bush and ring nut, which nut must be tightened up in the opposite direction from that in which the shaft is to revolve. Annular recesses at each end of the housing form pockets for the retention of the lubricant, and seal the bearing against access of dust or any other deleterious matter. When fixing the bearing, care must be taken that it is located centrally in its housing, to permit of actual equal lateral movements with changes of temperature.

Figs. 90 and 91 represent the standard housing which is used for the accommodation to existing hangers for adjustable bearings. It has two recesses to receive the adjusting screws that regulate adjustments in the vertical direction and permit a slight amount of swivel, and two side slots which receive the setting screws. In other respects the bearing resembles the plummer-block type. It includes the adapter sleeve, the provision for lateral movement, and the annular recesses for lubricant and seal. As the housing is not divided, as in the plummer-block fashion in Figs. 92 and 93, it is made in two portions, a cap covering one end making a sliding fit in the body. The bore of the outer race is continuous with the ring fitting, so that the race is easily inserted.

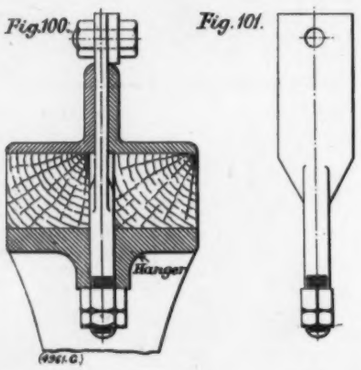
When hangers are supplied by the firm for new installations the housings are split horizontally, as shown in Figs. 94 to 96. The advantage is that the bearing can be easily inspected without the oil getting spilled or the bearing itself interfered with.

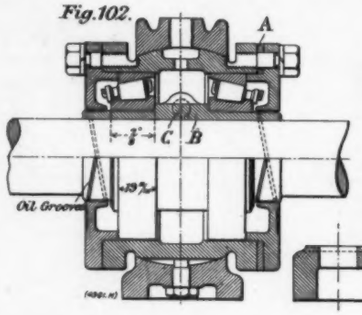
The system of mounting loose pulleys is shown by Fig. 97. The principle of construction resembles that of the standard housing in Fig. 91 in regard to the fitting of a removable end cap. When the cap is removed from the nut side of the adapter sleeve, and the nut run off from the sleeve, the bearings and balls can be pushed bodily along on the shaft. Replacing and tightening the nut, and the cover, the pulley is ready to run.

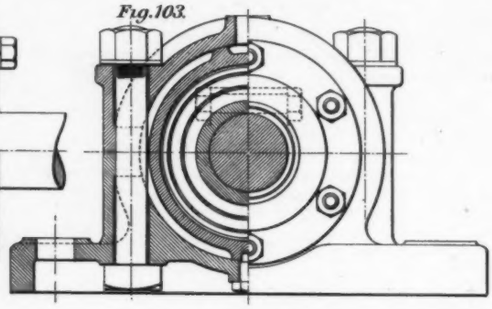
The general arrangement of a large installation of these bearings in the shops of Halley's Industrial Motors, Limited, Yoker, Glasgow, is outlined in Figs. 98 and 99, on page 191. Nine lines of main shafting run across the shop, each line being driven by an 80-h.p. motor, Fig. 98, on the floor. The motor makes 750 r.p.m., the shafting 180. The belt drive is diagonal, as seen in Fig. 99.

Each line of shafting totals to about 176 ft. in length, made up of 20-ft. lengths of 3-in. shaft, and shorter lengths at the driving end of 3½-in. shaft. The lengths are united with compression couplings. They run in light-type bearings carried in hangers 24 in. deep. The centre lines of the shafts are 26½ in. below the undersides of the principals. The method of fixing the hangers is shown by Figs. 100 and 101, subjoined, a central bolt being carried by the roof truss ties. The countershaft hangers, not shown, are carried on longitudinal stringers bolted to the undersides of the roof truss ties.

The Hyatt roller bearings, manufactured by Messrs. Broom and Wade, of High Wycombe, are characterised by the employment of flexible rollers, which accommodate themselves to irregularities in running, and so present a bearing along their entire length instead of making contact on high parts only. This is accomplished by making the roller of a strip of steel which is wound into a helix of uniform diameter. The rollers are disposed with the spirals running right and left-handed alternately, with the result that the oil is carried to and fro with equal distribution. The spaces also form reservoirs of oil, helping lubrication.







A strong feature claimed for this bearing is that it can be applied to shafting as readily as any other. Instead of being slid along from one end, with the necessity of dismantling any couplings and pulleys that come in the way, it can be located anywhere, as any other divided bearing can be. The box is divided, corresponding with a plummer block and its cap, and the cage is divided in halves similarly to solid brasses, each half cage carrying its half-complement of rollers. Another feature is that no inner race is required, but the rollers instead make direct contact with the shaft. The only race is fixed in the box, also in halves. Oil wells at each end of the box, with an oil wiper, prevent dripping. These bearings are constructed with boxes which can be used in plummer blocks, wall brackets, hangers, or for countershafts.

The Timken roller bearings, Figs. 102 and 103, made by Messrs. The Electric and Ordnance Accessories Company, Limited, Ward End Works, Birmingham, possess features by which they are differentiated from all other types. Having line contact, these bearings can be made smaller in diameter than ball bearings, to carry the same load. The tapered form of roller used has two great advantages, namely, wear can be taken up, and the same bearing will withstand radial load and end thrust, either combined or separately.

The Timken bearing comprises the conical rollers with their axes set on an angle with the axis of the shaft, the rollers running on the inner element, *i.e.*, the ribbed cone, which is similarly tapered, the line contact occurring between the ribs and not on the top of the latter, the ribs themselves maintaining the rollers in alignment and in their proper relative positions on the inner race. The rollers are retained as a unit with the cone by the pressed steel cage, made in one piece, which ensures the correct spacing of the rollers and also retains the lubricant. The unit is retained by the cup or outer race, which fits over the assembled cone and rollers. To remove slackness due to wear, the cone or inner race, with the set of rollers, is moved further into the cup. The rollers are of chrome steel, heat-treated, to combine the necessary toughness and hardness. The rollers, cups and cones, are hardened and ground, and the complete bearings are made in light, medium, and heavy types.

The general design for a line-shafting application is shown by Figs. 102 and 103, which illustrate a 1¼-in. plummer block. In this application the cone or inner races are made a press fit on the inner sleeve, which fits the shaft. Adjustment is effected by taking as much off the thickness of washer A, Fig. 102, as will remove all perceptible end play, care being taken to see that the bearings are not under any circumstances overtightened, but perfectly free to revolve after the adjustment is finally locked. The washer A referred to is separately fitted to each individual set of bearings when they are assembled. Provision is made for the expansion of the shafting by fixing the location of one plummer block on the line of shafting. This is done by fitting a sleeve B, Fig. 102, with the set bolt C, the other plummer blocks permitting the shafting to slide endwise through the inner sleeve.

METHODS OF SAMPLING DELIVERED COAL.

THE practice of purchasing coal under specifications depending upon the heating value and ash and moisture contents of the coal is spreading in this country, and it is certainly a more satisfactory and scientific method than the old practice of basing business transactions merely upon the reputation and trade name of a fuel. The analytical determinations and tests do not involve any particular difficulties or expense and can be performed with considerable accuracy. But experts may differ, and the settlement of disputes may lead to unpleasant and costly litigation. A great deal depends upon sampling in all tests of raw materials, and in coal more perhaps than in many other cases, because the coal mined is not exactly the coal delivered. The experience gained in the United States, as we see from Bulletin 116 of the Bureau of Mines, compiled by Mr. George S. Pope, is very instructive in this respect.

On the recommendations of the Technological Branch of the United States Geological Survey, the Treasury Department adopted the method of buying coal to specification in 1906. Other departments followed suit, and at present more than half the coal used by the Government over there—valued at about 8,000,000 dols. annually—is purchased under specifications. The Bureau of Mines Laboratory at Washington has tested more than 1,200 samples of coal in one month. In connection with the study of the coal deposits of the country more than 2,500 mines were visited by engineers and geologists, and from two to eight and more samples were taken in each mine; some of the results were published in 1913 (Bulletins 22 and 85), and a further publication is under preparation. A comparison of the analyses of the same coal from the mines and from cars shows that the mine samples are on average of a higher grade, higher calorific value and lower ash contents than the commercial samples. The reason is that the Government

inspector samples like an experienced good miner, and is more careful in rejecting slate, bone, mine roof and floor, &c., than the average miner, whose earnings depend upon the maximum number of tons which pass the tipple inspection. The expert's samples, moreover, are generally more moist, as they contain the full moisture of the mine air, and this moisture is an important factor.

Prior to the fiscal year 1912–13 the specification was based on the British thermal units as "received" basis, that is to say, payment was directly affected by the moisture content of the sample received by the laboratory. It was assumed that the moisture in the samples collected at delivery would be preserved, with but slight loss, during the storing, crushing, &c., of the gross sample for laboratory treatment; but the laboratory may find 5 and even 10 per cent. less moisture than is contained in the wet coal being weighed. In one instance 254 gross samples were reduced to samples of about 5 lb. each; these were divided into two equal parts, and the duplicates, placed in mailing cans, sent to the Bureau; the pairs of duplicates should have shown the same moisture percentage, but there were average differences of ¼ per cent., and the maximum difference was 3.6 per cent. These tests do not give any information as to the moisture lost by the gross samples in preparing the duplicates. That moisture is largely accidental and beyond control, as it varies from day to day in the same mine; yet a maximum permissive moisture is generally specified. When coal of uniform calorific "dry coal" value is delivered by contract, the contractor has the advantage when the moisture approaches the maximum allowed, while the purchaser profits when the coal is very dry. A contract calls, *e.g.*, for coal of 14,300 British thermal units (per pound of dry coal) and 3.5 per cent. moisture maximum. Let the average moisture of the coal delivered be 2.5 per cent., then for every ton (2,240 lb.) of dry coal having a heating value of 32,032,000 units the purchaser would pay for 56 lb. of water at the rate of the dry coal price. During the dry season the moisture may go down to 1.5 per cent., and the purchaser would pay too little. Buyer and seller should indeed share the uncertainty, but the stipulation of a moisture limit is not unfair. Coal weighed immediately after a heavy rain has been found to be 5 per cent. heavier than before the rain; the moisture would not be equally distributed through the bulk of coal and would be better retained by small coal than by big lumps. To meet such cases, the regulations call for "special moisture samples" when there is excess of moisture. Placing the heating value on the "dry coal" basis, with a maximum moisture percentage, eliminates the need of frequent corrections of price on account of uncertain moisture variations.

There is not much trouble as regards ash contents —intrinsic ash and extraneous mineral matter. But the specifications as to volatile (partly incombustible) matter have caused disputes. The Bureau of Mines recommends that practical service tests should be made to determine the relative suitability of the coal offered, concerning which the furnace construction should be considered. The United States departments do not regard as equitable any scheme of applying penalties on account of variation in volatile matter, but they may reject a coal when marked deviations from the specified volatile matter content suggest substitution of another coal. Some municipalities and firms, however, provide for a correction of 2 per cent. in price for every 1 per cent. of volatile matter in excess of the standard guaranteed, although even careful analyses may differ by several per cent. in this respect. Some purchasers are also very exacting as to excess of sulphur, which is, with little justification, charged with forming or increasing the clinker, though clinker formation depends more on oxidic ash and conditions of firing. Too rigid specifications have done much to discredit the specification method.

The elaborate recommendations for coal sampling made by the Bureau of Mines are substantially in accord with the proposals made by E. G. Bailey, in 1908, for coal sampling, and by D. W. Brunton, in 1895, for ore sampling in general, and, further, with the tentative method suggested by the American Society for Testing Materials in 1915. Gross samples should be of large bulk, 1,000 to 1,500 lb., no matter whether the coal delivery consists of 1 or of 500 tons; for large cargoes of 5,000 tons and above the Bureau recommends gross samples of even 3,000 and 4,000 lb. Where deliveries are fairly regular, one or a few gross samples per week may suffice. The samples will be best collected while the coal is being loaded or unloaded from cars and ships or dumped from wagons; once the coal is stored in bins or piles or loaded on cars and vessels, representative samples cannot easily be obtained. During loading and unloading shovels taking from 10 to 30 lb. may be used; with shutes and conveyors a certain portion should be continuously diverted for sampling; the personal element is then eliminated; otherwise there is too much tendency to picking out good or bad specimens. The sample should also contain the same portions of lump and of fine coal as the bulk. Where coal is distributed to various points, sampling should take place at the source of supply. The Bureau has charge of the sampling of cargo shipments of coal from the Virginian ports to the Isthmus of Panama for the Panama Railroad. At the docks, portions of 30 or 60 lb. are collected from every car dumped; a ladle of 30-lb. capacity is used which is rested on the rails of the track or on the chains which support the gates of the car. Two ladlefuls are usually taken from a car, one from each side or each end. The drop of the coal from the opened gates may be too sudden, and the momentum too great to allow of placing the ladle in the stream of the falling coal; in those cases the shovels are applied to overflow piles on the piers. As the collection of the entire sample may take hours, or even a few days, metal (or wooden) receptacles with airtight lids to hold the 1,000 lb. have to be provided.

It is clear that under the conditions indicated accurate moisture tests could hardly be performed, and that the above-mentioned "special" moisture test will usually become necessary. For this purpose the gross sample is rapidly crushed to pass a 1-in. screen, which is done in a comparatively cool place, protected from rain and sunshine, and portions of about 1 lb. are taken from the first conical pile made—as we shall presently see—by the aid of a scoop, 8¼ in. long, 2½ in. wide, with sides 2 in. high. When the collection of the gross sample may take several days, about 100 lb. are accumulated in specially-sealed vessels; from 30 to 50 lb. of coal will be wanted for the moisture tests.

The preparation and reduction of the sample for analysis is to be carried out in seven stages. In the first stage the 1,000 lb. of the gross sample are crushed to 1-in. size, on rust-free sheet iron, or on floors of wood, cement, &c., which should be free of cracks and splinters. The crushed coal is piled to a cone, each shovelful being spread on the top of the preceding one, the man walking round the cone during this operation to ensure uniform distribution. The cone is transformed into a pile, 5 to 10 ft. in length, by spreading alternate shovelfuls from the right or left; the mound is then halved by piling alternate shovelfuls on one of two cones, one of which is rejected. The resulting sample of 500 lb. is, in the second stage, crushed to ¾-in. size and again halved by the same sequence of operations. In the third stage (starting with 250 lb.), crushed now to ½-in. size, the pile is flattened out and quartered by means of a board applied edgeways; two opposite quarters are rejected. The other two quarters are, in the fourth, fifth and sixth stages, crushed to ¾, ¼ and $\frac{5}{16}$-in. size and coned, then mixed by rolling on a blanket, coned again, flattened out, and halved by the quartering operation. Thus, finally, two samples of 5 lb. each are obtained which are sealed in containers, one for analysis, the other for reserve and control. The sample should entirely fill the container, to avoid shaking of the coal on transport. The Bureau recommends two forms of container, the one made of galvanised iron, the other of wood into which a pressed paper case fits.

The operations can be facilitated and accelerated by the aid of various devices. There are, for instance, sampling and mixing boxes and buckets, so built up of narrow parallel compartments, alternately closed and open, that the mixing also divides the sample into two equal halves. In the classification of the coal, coal for steam and heating plants (bituminous and small-size anthracite) is distinguished from large-size anthracites (broken, egg, chestnut, stove) for domestic heating. As regards bituminous coal, 2 per cent. variation is allowed from the guaranteed British thermal units before making any price correction. In the case of the coal for the Panama Railway, the two analyses of samples of the same cargo generally agree within 50 British thermal units, while with 14,000 British thermal units, dry bituminous coal, the calorific value might vary between 13,720 and 14,280 units before any price correction question would be raised. Thus the method, which is less troublesome in routine practice than it might appear, seems to answer. The Bulletin, we should add, reprints the specifications for the purchase of coal for the United States Government, and warns in these against the custom of some coal firms of offering—for the sake of advertisement, chiefly—in their tender a fuel of higher calorific value and lower ash contents than their coal warrants. The price bid would be correspondingly higher than the price actually received, the firm being prepared to have to accept a deduction. This mistaken policy may lead to the rejection of the coal or to the infliction of heavy penalties.

TELPHER INSTALLATION AT THE DALMARNOCK GAS WORKS, GLASGOW.

By G. F. ZIMMER, A.M.Inst.C.E.

(*Concluded from page 153.*)

FIG. 35 on Plate XVII, published with the present issue, shows the telpher passing over the ferro-concrete coke bunkers to the place allotted for the coke to be stored in the open, while Figs. 36 to 53 on the same plate show the constructive details of the trestles mounted on these bunkers. The positions of these trestles will be clearly seen on reference to the view, Fig. 2, published on page 156 of our issue of February 16.

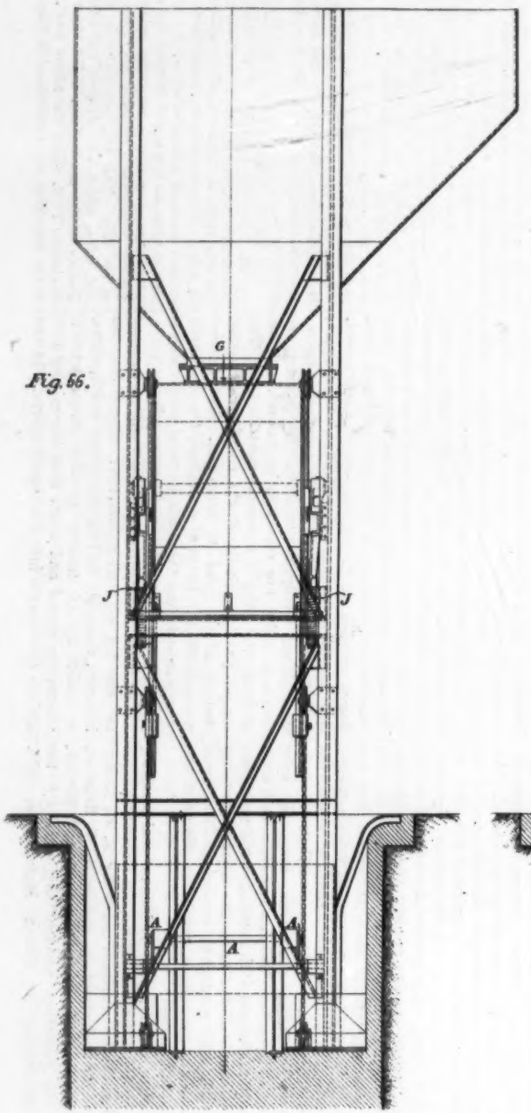
These reinforced concrete coke bunkers represent an ideal arrangement for holding coke of different sizes so that it can be withdrawn with practically no hand labour. The total capacity of the bunkers is 4,000 tons; they are divided into two sections, which in turn are subdivided into a series of compartments by longitudinal and transverse walls so that the coke can be stored in four different sizes ready for delivery by gravity. The arrangement of the compartments is shown by the transverse and longitudinal sections and the plan given in Figs. 58 to 60 on page 194. The overall dimensions of the bunkers are 104 ft. long by 84 ft. wide by 48 ft. high from rail level, and they are supported on reinforced concrete columns varying in size from 18 in. to 36 in. square. The loads on the main columns are upwards of 300 tons each, and as the ground was not considered capable of taking more than 1 ton per square foot, special continuous footings had to be arranged for each row of columns.

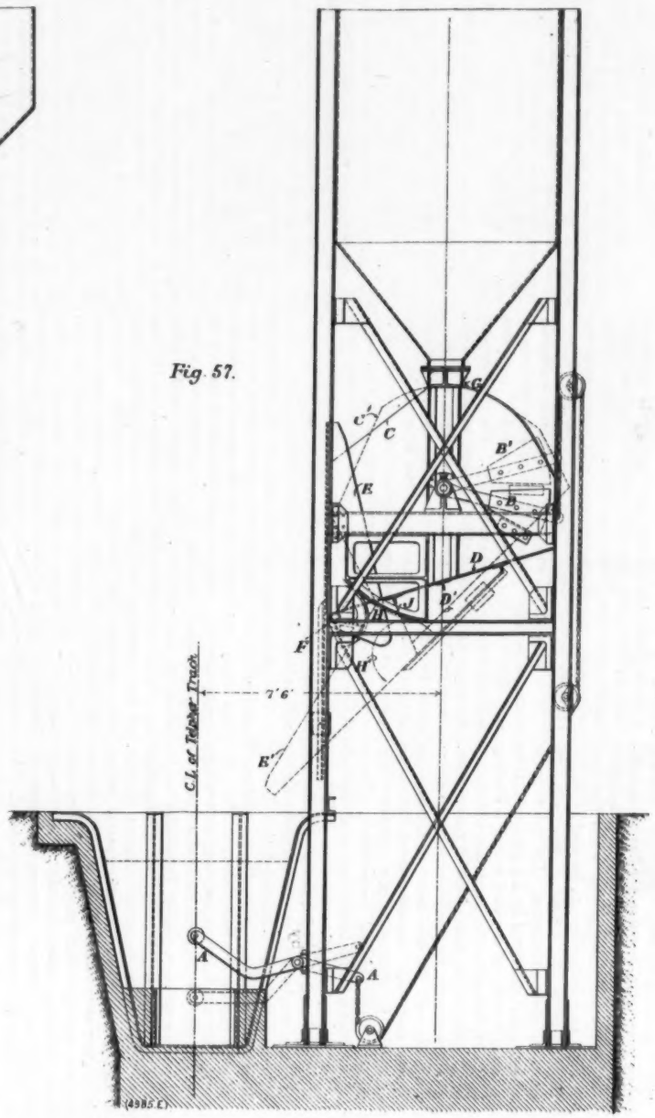
The hopper bottoms to each compartment are 8 in. thick, and sloped at an angle of about 45 deg., and at the lowest point above rail level they are at a height of 10 ft. to allow sufficient clearance for railway wagons and carts to pass underneath to receive the coke, the latter being discharged from the hopper valves. Owing to the compartments being of various sizes, necessitating divisional walls of exceptional length without break, these walls had to be stiffened by the introduction of vertical beams connected by cross-ties and bracings from side to side of the bunkers. The outer walls are also stiffened by vertical beams projecting outwards at even intervals throughout the length, and being connected to the top and bottom horizontal beams, forming panels, as seen in Fig. 2 on page 156 *ante*. The designs for these bunkers were prepared and the work carried out, on their "Lattice" and "Keedon" system, by Messrs. Johnson, Clapham and Morris, Limited, Manchester, the sub-contractors for the concreting being Messrs. Macdonald and Mackinlay, of Glasgow.

The Automatic Revolving Skip-filler.—In order to keep up the specified capacity of 60 tons per hour per machine, it was imperative to devise a means for filling the skip with its 3¼-ton load of coal with a minimum of delay, and automatically, from the receiving bunker, so that no hand labour whatever is required to fill the telpher skips, as this would be much too slow. The skip-filler adopted, which is mounted below the receiving bunker, consists of a rotating box of the same capacity as the skip. This box is actuated by balance-weights and trips, which are released automatically by the descent of the empty skip, whilst the telpher remains stationary 77 ft. above the filling level. Photographs of the skip-filler are reproduced in Figs. 54 and 55 on

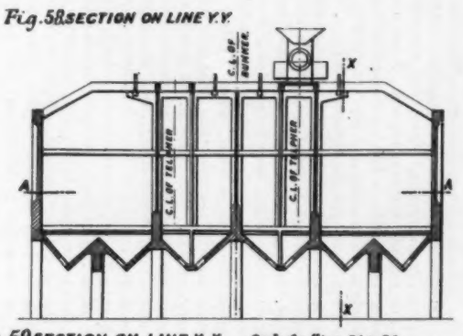
TELPHER INSTALLATION AT THE DALMARNOCK GAS WORKS, GLASGOW.

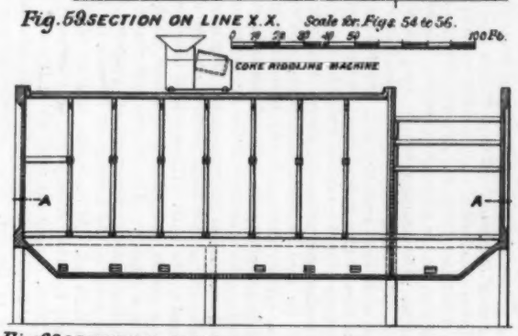
MR. ALEXANDER WILSON, M. INST. C.E., ENGINEER; MESSRS. STRACHAN AND HENSHAW, LIMITED, BRISTOL, CONTRACTORS.

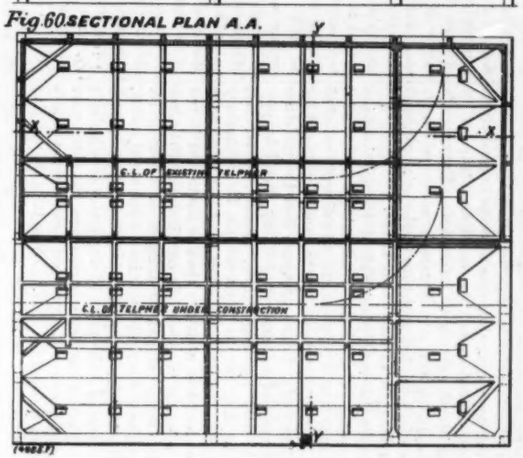




FIGS. 56 AND 57. SKIP FILLER.







FIGS. 58, 59 AND 60. SECTIONS OF COKE BUNKERS.

TELPHER INSTALLATION, DALMARNOCK GAS WORKS.

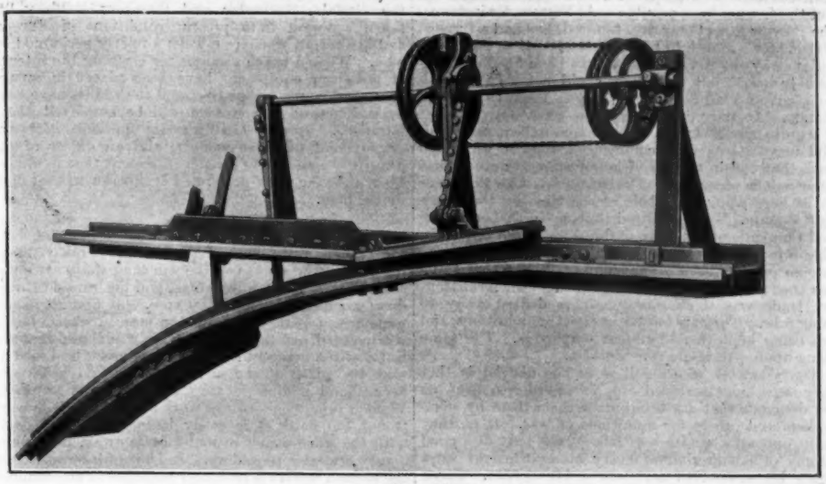


FIG. 61.

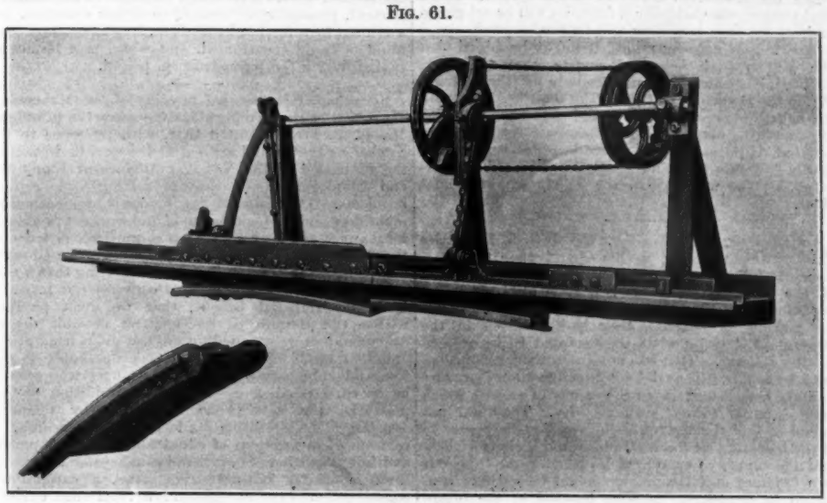


FIG. 62.

FIGS. 61 AND 62. SWITCH GEAR FOR TELPHER LINE.

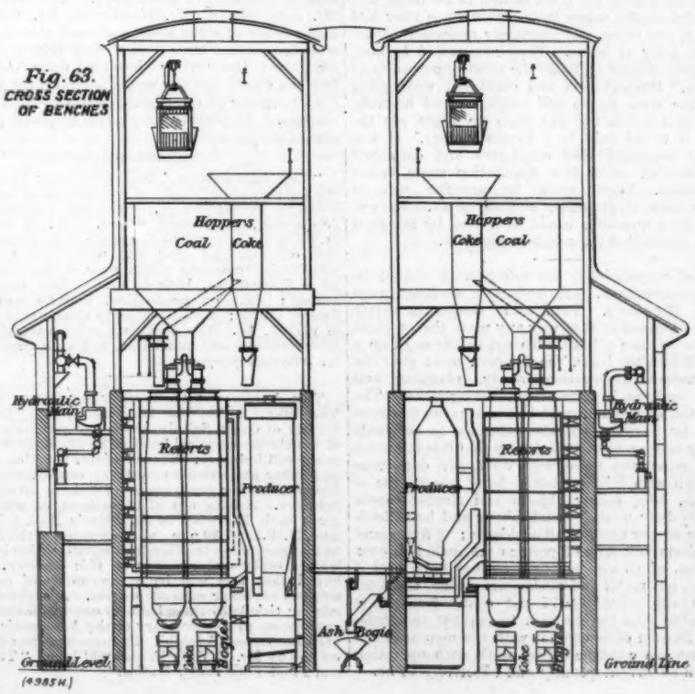


Plate XVII, while Figs. 56 and 57, on page 194, show the structural details.

The rotatory box is suspended on trunnions on the main frame of the structure in such a way that when full the bias is in front, *i.e.*, it will rotate towards the skips to be filled. When the box is empty the bias is on that side remote from the skip, and it will therefore return automatically into the original position. Two weights are employed which will overcome the tendency of the full box to rotate forward, and these weights are removed at the moment when the skip is ready for its load.

The rotatory box is of such construction that in the discharging position there is sufficient inclination for the coal to run out freely and instantaneously through the front opening. The shoot, which leads the coal well over the centre of the skip, is only in its discharging position for an instant, and is then moved out of the way of the skip again.

The action of the automatic skip-filler will be understood by reference to Figs. 56 and 57, and is as follows:—When the skip is lowered from the telpher into the pit guides it depresses (on reaching the extreme bottom position) the levers A, and consequently the balance-weights B, which latter rest normally upon angle-iron cleats attached to the rotating box C. The weights B are then in the position B^1, and the bias is therefore removed from that side of the box C, and the centre of gravity of the full box is on the other side of the trunnion. The box therefore rotates to the position C^1, and thus changes the inclined bottom from position D to D^1. The coal now slides towards the front against the shoot E, which is pivoted to the box C at F, and simultaneously the coal supply to the box is cut off at G by the movement of the cylindrical back of the box.

On the centre F, and fixed rigidly to the shoot E, is a sector of a circular gear H; this gear travels along the fixed rack J, and thus rotates the shoot E on its centre F until it reaches the lower position E^1, when it stands over the skip (which by this time has reached the bottom of the pit), and the whole contents of the box C are shot cleanly into the skip. The centre of gravity of the empty box C is now on the same side as the balance-weight B, and the box is therefore restored to its original position, the valve G is opened, and the new charge drops into the box from the bunker above it. During the restoration of the box to its original position the gear H, on the centre F, travels in the reverse direction over the rack J, and the shoot E is thus raised clear out of the path of the full skip, which is now lifted by the telpher. The whole operation of charging the skip only occupies about 10 to 15 seconds.

The photographic view, Fig. 55, on Plate XVII, shows a near view of the device, while in Fig. 54 a view of the complete receiving terminal is given which shows the bridge over Adelphi-street between the trestles A and B.

Track Switch.—Considerable difficulty has been generally experienced in devising a reliable and safe method of diverting the telpher machine on to branch tracks from the main line, the essential points being the smooth running of the machine over the junction and suitable provision in the overhead trolley wire equipment, which, of course, must operate simultaneously with the switching of the track, or the telpher would come to a standstill.

In the switch used in this installation all such difficulties have been overcome, and the system is easily applicable to either single, double or treble overhead wiring; it can therefore be used for direct current, as well as for one, two and three-phase alternating currents. Some of the most important features of the switch, which is illustrated in Figs. 61 and 62 annexed, may be summarised as follow:—

The continuity of the main track joist is not broken or interrupted in the least by the introduction of this switch; thus the tendency of the track end to spring when the switch is opened is avoided, and the rigidity of the track thereby maintained. There is no difficulty in mating up the end of the moving rails with the fixed rails, thereby the telpher machine negotiates the points smoothly.

The operation of the switch is a very simple matter. All that is necessary is half a revolution of the chain-wheel with its spindle; the fellow-wheel carrying the chain can be fixed to any convenient spot as long as the chain comes within easy reach of the telpher man. There is nothing elaborate about the gear, it is of simple and substantial construction, as may be seen from the illustrations, Figs. 61 and 62, and can be operated practically instantaneously with ease. The switch is self-locking in either direction. If necessary the operating chain could be extended to the ground-level by placing the second chain wheel there, with an additional locking arrangement, so that it could not be tampered with by any unauthorised person.

The movement of the overhead wiring switch synchronises with that of the track switch, and a smooth path is provided for the current collector trolley, so that the switch is traversed without the occurrence of jerks or sparking. If it should be desired

the current may be cut right off from a branch of the track which may not be in use. This has been found to be of considerable advantage when it is necessary to carry out any repairs to the overhead equipment or to the telpher itself, as then the work can be carried out without running the risk of electrical danger.

Fig. 63, on page 195, is a section through the retort house and shows the position of the telpher installation with regard to the retorts and gas producers. In conclusion we may state that the total cost of the telpher structure, three telphers, skips, grabs, electrical trolley-line, and skip-fillers, was, approximately, 6,500*l.*

INDUSTRIAL NOTES.

AT the annual meeting of the shareholders of Crossley Brothers, Limited, held at the Memorial Hall, Manchester, last Monday, Sir Kenneth Crossley, Bart., chairman of the Board of Directors, after dealing with the affairs of the company, said he believed that British industrial opportunities would be greater in the future than they had ever been in the past. The new methods of manufacturing and the interchange of views between employers themselves, and, also, he was glad to add, between employers and employed, would bring real benefit. We had all to learn to look with broader minds on the subject of wages and output. Pre-war disputes were more or less private quarrels, sometimes almost enjoyed even by the victims. From now onwards, however, they would be national calamities, when the whole future of the Empire depended upon making up for past wastage. Most employers would now admit that high earnings were no bar to progress—in fact, just the reverse—provided only that the work-people themselves would honestly try to do as much as possible during working hours. Then, indeed, we should all be prosperous.

The Merseyside engineers decided by ballot last Sunday to accept the award of the Committee, of Productions of War of 4*s.* weekly war bonus. The men had claimed a bonus of 10*s.*, and the point had been under consideration by them for the last week or so. There voted for acceptance of the 4*s.* bonus 1,700; against, 1,410; a majority of 290 in favour.

A number of Middlesbrough works managers, interviewed with regard to the Prime Minister's suggestion for increasing iron output, all agreed, says the *Yorkshire Post*, that the most serious trouble was the labour question, and declared that, unfortunately, in many cases the men were not giving of their best. Loss of time was serious, many men failing to turn out for the early morning shift four and five mornings per week. Even men returned from the Army were great offenders in this respect.

Mr. Harry Dock, president of the Cleveland Ironstone Miners' Association, in course of conversation, stated that certain inquiries were being made in the district on behalf of the Ministry of Munitions, and further development was expected. He was quite certain that there was plenty of good iron ore in the Cleveland district which could be worked for munition purposes, but the question of man-power was the problem. Early in the war some 20 to 22 per cent. of the miners joined His Majesty's Forces. He had suggested that men should be released from the Army to win ironstone, and this was being done slowly. Only men who had worked in the Cleveland district, and who knew the work of the Cleveland mines, should be sent, because a trained Cleveland miner was worth quite three men who had not been used to the work. Until the Cleveland Miners' Executive had considered the matter, he did not care to commit himself further.

Mr. Thomas M'Kenna, Secretary to the Cleveland and Durham Blastfurnacemen's and Cokemen's Association, in the course of an interview said:—"Pig-iron is certainly the crux of the whole military situation. There are hundreds of millions of tons of ores in the Cleveland hills, but the difficulty of increasing the ore supply will be that of opening out new mines, or of re-opening old ones, and this could not possibly be attempted without adequate supply of labour. During the past six months six additional furnaces have been put into operation in the Cleveland district, which should mean an increase of between 4,000 and 5,000 tons of pig-iron weekly. The work at the 76 furnaces now in blast is being carried on with the minimum number of men. Before additional furnaces can be put to work the skilled men necessary must be relieved from military service. At the outbreak of war 1,200 practical blastfurnacemen enlisted from the Cleveland district, and as a consequence the output at that time suffered a material reduction. The only way we can see for starting new furnaces is by the return of sufficient of these men from the Army."

The same journal deals with the situation in the Barrow-in-Furness district, and says that the shortage in the supply of hematite iron ore has been keenly felt there for some time. Smelters have been pressed to give deliveries of iron, and in various parts of the district furnaces have been prepared with a view to relighting, but this has not been possible. At Barrow, for instance, the Barrow Steel Company, Limited, has had a furnace waiting for a month to be put into operation, and a few miles away the Askam Iron Works have been in readiness to start, but as makers could not rely upon a constant and regular supply of ore, there the matter stands. At the mines there is a great activity, but it is quite possible for a heavier output to be maintained, and negotiations were commenced a short while ago with that end in view, and hopes are entertained that these will be successful. The suggestion is for the mines to be kept going the whole of the time by the three-shift system. It is admitted that in North Lancashire and Cumberland there are millions of tons of ore available if it can only be worked. To meet the deficiency foreign ore has been largely imported, but that trade has been handicapped. Some years ago, when the iron-ore trade was slack, many miners drifted away to other jobs. They are mostly engaged on munitions, and are being kept there by their employers. The same thing applies to many iron workers.

The views of iron smelters in the district is that they must have increased supplies in order to meet the big demands that are being made upon them by steel-makers and others for munitions of war. It is, they point out, all a question of labour, not only of a good supply of labour, but of every miner when at work doing his utmost to maintain a big output. Given that output, then additional furnaces will be set going, and all the iron necessary will be forthcoming.

Apart from existing mines, it might be added that the Millom and Askam Hematite Iron Company, Limited, is opening out a new iron-ore pit, the Florence Pit, in the Egremont district. The shaft has been sunk to almost the necessary depth, and soon a good quality of ore will be obtained. The Barrow Steel Company, Limited, is developing its Yarlside property, and the North Lonsdale Iron and Steel Company, Limited, is extending the workings in the Thirty Pit at Lindal Moor.

On opening, last Monday, the British Industries Fair at Glasgow, Mr. Neville Chamberlain, Director-General of National Service, said it was to the credit of the manufacturers that, despite difficulties by depletion of staffs and want of transport facilities for the getting of material, they had persisted in the attempt of showing what they wanted to be able to do after the war. That was not an ordinary exhibition, but a trade fair. They did not intend to allow Germany to make herself mistress of the supply of articles which were essential to our own security. They did not intend to find themselves in the position they were in at the beginning of the war, and would no longer allow that the supply of many articles which came from our own Colonies and Dominions should be entirely controlled by Germany. Looking forward to the future if we were to establish our commercial position after the war, if we were to find work for the millions of men who came back from the front as well as for those who had so patriotically taken their places when they had been away, one thing was absolutely necessary—there should be unity at home. There, it seemed to him, was the great danger and also the great opportunity of the future. If employers and employed were going back to the same doubt and suspicion and hostility which existed before the war, then we might win the war, but it would only be a barren victory. It was absolutely necessary that employers and employed should establish on a firm foundation some better understanding. There must be sacrifice not of prosperity, but of prejudice and old ideas. He was confident such questions would be settled by the good sense and goodwill of the people themselves.

The final responsibility for safety work cannot be placed on committees, gang leaders or workmen, says *Canadian Machinery*. Practicable results in safety cannot be obtained in that way any more than a plant can be run on such a basis. To put safety work on a sound and sensible basis, the foreman must give the subject serious observation, study, planning and direction, such as is given to operating work. The safety of the workmen always has been given foremost attention by foremen, but the reduction in accidents effected by many companies indicates that this attention has been concerned more with obviously dangerous factors than with injuries due to hand labour, use of hand tools, falls, falling objects and similar causes incident to daily work. Hand labour and hand tools cause over 40 per cent. of all accidents; if flying and falling objects and falls of persons are included, over 60 per cent. of all accidents are represented; and if burns from hot metal and cinders are added, the total represents approximately 75 per cent. No one is more capable than the foreman to prevent accidents, no one is in such close contact with the men as he is, and no one can combine safety work with operating supervision so advantageously and effectively as he.

We read in the *Railway Review*, Chicago, that owing to the scarcity of labour during the past few months, the Buffalo, Rochester and Pittsburg Railway has taken a lesson from present conditions in Europe, and has placed women on work formerly performed by men. Women coach cleaners for cleaning the interior of passenger equipment have been placed in service at several points on the line, and the results have been so satisfactory that women will be employed at all terminals. Special facilities are provided for the employment of these women, and an officer of the company is authority for the statement that in almost every case the work performed is superior to that done by the men.

The same American journal also states that both the Canadian Pacific and the Grand Trunk railways report that the women workers in their shops are doing admirably, being willing, quick, and not afraid of even dirty work hitherto done by men. At first there was some resentment voiced by the male workers, but it was pointed out that male labour was short, that the work was urgent, and that women must be asked to take the place of the men. Women and girls have been found willing to take up such work as offers. Women take to munitions work agreeably. The work is not too hard, it is easily learned and well paid; with the wage-earner in many cases away, it becomes a very desirable procedure. A point of interest is that the woman worker is no longer regarded as an economic portent, presaging all sorts of economic disasters, but a normal feature of industrialism, to which the general mind is being accustomed, and which will be accentuated during the reconstruction period.

Speaking at the annual meeting of the Manchester Chamber of Commerce, held last Tuesday, the president, Mr. R. B. Stoker, stated that, with reference to the conditions that would arise after the war, he welcomed the formation of the National Alliance of Employers and Employed as a means of solving some serious problems. The demand for renewals, replacements, rebuilding and restocking would find work for producers for many years, if proper measures were taken to derive the greatest benefit from the situation. The Government showed increasing signs of recognising that a new world awaited us, that we must conserve our Imperial trade for Imperial benefit, that we must produce within the Empire to the greatest possible degree every product we required for our use and consumption, and that never again must we open our house to the free and unrestricted use of the stranger who offered us no corresponding hospitality. In addition to this must be the active encouragement, by financial assistance, of scientific and technical research, a revision of our system of education, the development and full utilisation of our inland canal system, a drastic revision of our naturalisation laws, a careful re-consideration of our navigation laws, and other evident necessities.

In regard to the worker, added Mr. Stoker, we might look forward with great hope. The utterances of Mr. John Hodge, Mr. Henderson, Mr. Roberts, and many other of their leaders showed that a new spirit was dominating their views, that they in their turn recognised the terrific burdens upon our national finances which this war would leave behind it, and the vital necessity of the utmost limit of production being reached. Employers were quite prepared properly to reward proper service.

"THE IRONMONGER" METAL MARKET YEAR-BOOK.—We have received a copy of this year-book for 1917, the eleventh annual edition, edited and published by *The Ironmonger*, 42, Cannon Street, E.C., at the price of 3*s.* 6*d.* net. It contains 270 pages of statistical information on iron and steel and non-ferrous metals, the information covering prices over a number of years, price fluctuations, both in the United Kingdom and abroad; data on production, imports and exports; lists of extras; particulars as to restrictions in dealings in metals, &c. The book is a most valuable guide to manufacturers and merchants, and an interesting source for reference purposes.

THE AERONAUTICAL SOCIETY OF GREAT BRITAIN.—Yesterday, under the auspices of the Aeronautical Society of Great Britain, there was inaugurated a series of weekly aeronautical lectures for the benefit of workers in aircraft industry. These lectures have been organised to further the scheme now being urged forward by the Government for the purpose of linking up science with industry. Arising out of these lectures, which will be given each Thursday in St. Peter's Hall, Cricklewood-lane, N.W., at 7.30 p.m., a local section of the society will be inaugurated in the Hendon district, which is one of the largest centres of aviation in this country, and it is hoped that this will be a forerunner of many other sections at other aircraft centres. A syllabus and admission tickets to these lectures can be obtained free on application to the secretary of the Aeronautical Society, 11, Adam-street, Adelphi. The next lecture, on March 18, will be by Mr. E. S. Relf, and will be on "The Aerofoil and Fluid Flow round Bodies."

NOTES FROM THE UNITED STATES.

PHILADELPHIA, February 2.

LARGE quantities of steel and munition material are being sought for by European buyers. The latest inquiry is for 100,000 tons Bessemer pig-iron for France and Italy. The aggregate of inquiries now pending for bars and forgings covers over 100,000 tons, besides inquiries of magnitude for munitions and cars. Canada is in the market for large quantities of shell steel, which must be had from this side of the line. Europe also wants large quantities of rails and plates. So far only 5,000 cars of the 20,000 cars wanted by France have been placed. France could use 40,000 cars. Spain, Porto Rico and Cuba are all in the market. Prices are still rising. The phenomenal profits of the United States Steel Corporation are attracting wide attention and will stimulate expansion of capacity still further. Shipments continue to be hampered by inadequate transportation. Conditions around Pittsburg in this respect are even worse. Carnegie pig-iron production is at present off 30 per cent. Shipments are piling up at the mills. Domestic business is crowding in at all the greater industrial establishments, especially locomotive and car shops. The Pennsylvania Company will build 225 engines, 92 all-steel passenger cars, and 2,100 freight cars, nearly all for use on the trackage east of Pittsburg and Erie. It is difficult to obtain a clear perspective of the situation in steel and railroad equipment. A very large volume of business is awaiting acceptance, and much of it will have to wait some time. Tools, implements for agriculture, and semi-finished steel are all in most urgent request. Meanwhile incoming capacity is rapidly adjusting itself to the market conditions.

ELECTROLYTIC CORROSION OF STEEL.

TO THE EDITOR OF ENGINEERING.

SIR,—Water containing carbonic dioxide is electrolytic at adjacent anodic and cathodic areas in a steel surface. These areas may be revealed by use of an indicator of phenophthalein and potassium ferricyanide. Where iron dissolves a blue, and at cathodic spots a pink, reaction is obtained. Observations by the microscope during these reactions should be directed as to resolution, &c., by a working hypothesis of their nature. The physico-chemical mechanism of change has first to be apprehended before control can be evolved or even sought. These reactions, expressed in chemical equations so far as is possible, are solicited, together with any remarks on their validity.

Yours truly,
"DERFLA."

Gibraltar, February 17, 1917.

[This subject was discussed in a paper read before the Iron and Steel Institute in May, 1909, by Mr. Allerton S. Cushman, and reproduced in ENGINEERING on May 21, 1909.—ED. E.]

DECREASE IN H.P. OF INTERNAL-COMBUSTION ENGINES DUE TO ALTITUDE.

TO THE EDITOR OF ENGINEERING.

SIR,—Since the outbreak of the present war the military use of the aeroplane has been exceedingly extended, and a marked progress in its design, construction and operation has been effected. On the other hand, the means of defence against the attack of the aeroplane has also seen several improvements to reduce the danger, and the shooting range of the anti-aeroplane artillery has been very much widened. The aeroplane, being liable to be attacked from below, has now to fly at an altitude of somewhat over 3,000 metres. The reduced density of air at a high altitude lessens the amount of oxygen to be drawn into an engine cylinder, which decreases in turn the consumption of the fuel, so that an internal combustion engine does not develop as much power at a higher altitude as it does at a lower level.

The decrease in horse-power of an internal combustion engine due to altitude may approximately be expressed as follows:—Since the volume of fuel gas to be sucked into an engine cylinder may be taken as constant irrespective of altitude, the volume percentage of oxygen in the atmospheric air being practically constant up to an elevation of several thousand metres, its heating value varies as its density. The horse-power developed by the engine does, therefore, vary as the density of the fuel gas, which may be taken to change in proportion to the variation in the density of the atmosphere. The horse-power of an engine at a high altitude is, therefore, found by simply multiplying its horse-power at sea-level by a fractional number denoting the specific density of air at the altitude referred to the air at sea-level.

Let—

p_o = pressure of the atmosphere at sea-level,

p_h = pressure of the atmosphere at an altitude of h metres,

T_o = absolute temperature of the atmosphere at sea-level,

T_h = absolute temperature of the atmosphere at the altitude h.

δ = specific density above specified.

Then we have—

$$\delta = \frac{p_h \times T_o}{p_o \times T_h} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

We find the following formula in a text-book devoted to the thermodynamics of the atmosphere—

$$\log_e \frac{p_o}{p_h} = \frac{h}{8000\,(1+0.00367\,t_m)} \quad . \quad . \quad (2)$$

where t_m is the mean of the atmospheric temperatures in deg. C. between the altitudes of zero and h metres.

To determine the value of t_m in the above formula we should know the atmospheric temperatures at different altitudes and find a law, if any, expressing the relation between the atmospheric temperatures and altitudes. Now, referring to the temperature-altitude curve for Europe given in the text-book, we find that the change in the atmospheric temperature may, up to 5,000 metres and thereabout above the ground, be very closely expressed as a linear function of altitude h.

Thus:—

$$t_c = 0.005\,h \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where t_c = change or decrease in the atmospheric temperature in deg. C. due to an altitude of h metres.

Let—

t_o = temperature of the atmosphere in deg. C. at sea-level,

t_h = temperature of the atmosphere in deg. C. at an altitude of h metres.

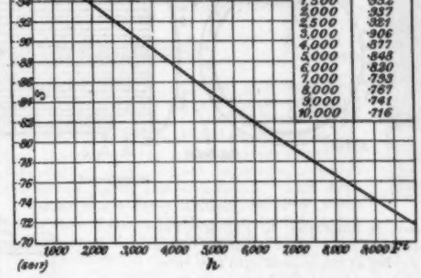
Then we have—

$$t_m = \tfrac{1}{2}\,(t_o + t_h)$$
$$= \tfrac{1}{2}\,\{t_o + (t_o - t_c)\} = t_o - \tfrac{1}{2}\,t_c$$
$$= t_o - 0.0025\,h \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Using this value of t_m in equation (2) we have—

$$\log_e \frac{p_o}{p_h} = \frac{h}{8000\,\{1 + 0.00367\,(t_o - 0.0025\,h)\}} \quad . \quad (5)$$

SPECIFIC DENSITY OF AIR REFERRED TO THE NORMAL AT SEA-LEVEL.



If h is measured in feet and t_o in deg. F., equation (5) becomes—

$$\log_e \frac{p_o}{p_h} = \frac{h}{26246.7\,\{1 + 0.00204\,(t_o - 32 - 0.00137\,h)\}}$$

$$\therefore \frac{p_o}{p_h} = e^{\frac{h}{26246.7\{1+0.00204(t_o-32-0.00137h)\}}} \quad . \quad . \quad (6)$$

From equation (3) we have—

$$t_h = t_o - t_c = t_o - 0.005\,h,$$

which becomes, if measured on the absolute scale—

$$T_h = T_o - 0.005\,h.$$

Hence,

$$\frac{T_h}{T_o} = 1 - \frac{0.005\,h}{T_o} \quad . \quad . \quad . \quad . \quad (7)$$

If the temperatures be measured on the absolute scale of the Fahrenheit system and altitudes in feet, equation (8) is obtained for equation (7)—

$$\frac{T_h}{T_o} = 1 - \frac{0.00274\,h}{T_o}$$
$$= 1 - \frac{0.00274\,h}{t_o + 460} \quad . \quad . \quad . \quad (8)$$

Now equation (1) may by means of equations (6) and (8) be expressed in terms of t_o and h as follows—

$$\delta = e^{-\frac{h}{26246.7\{1+0.00204(t_o-32-0.00137h)\}}} \times \frac{1}{1 - \frac{0.00274\,h}{t_o+460}} \quad (9)$$

If we take t_o = 32 deg. F., equation (9) is simplified to the following—

$$\delta = e^{-\frac{h}{26246.7\{1-0.0000028\,h\}}} \times \frac{1}{1 - 0.0000056\,h} \quad . \quad (10)$$

The value of δ calculated by equation (10) is given in the following table:—

h in ft.	δ	δ'	h in ft.	δ	δ'
0	1·000	1.00	4,000	0·877	0·88
500	0·984	0.98	5,000	0·848	0·85
1,000	0·968	0·97	6,000	0·820	0·82
1,500	0·952	0·95	7,000	0·793	0·79
2,000	0·937	0·94	8,000	0·767	0·77
2,500	0·921	0·92	9,000	0·741	0·74
3,000	0·906	0·91	10,000	0·716	0·72

The accompanying diagram is obtained by plotting the value of δ obtained from the table on the base of altitudes in feet. The line in the figure is slightly curved.

Rounding off the value of δ to obtain two significant figures after the decimal point we get the value of δ' given in the above table, which is very closely represented by the following linear equation in altitude h—

$$\delta' = 1 - 0.000003\,h, \quad . \quad . \quad . \quad (11)$$

in which h = altitude in feet.

The ratio of the horse power of an internal combustion engine at a certain altitude to that of the engine at sea-level is given by either δ or δ'.

Yours truly,
KANGO TAKEMURA,
Assistant Professor of Mechanical Engineering, Engineering College, Tokyo Imperial University.

December, 1916.

IMPERIAL PREFERENCE IN TRADE.

TO THE EDITOR OF ENGINEERING.

SIR,—As the expression of a pious wish, there is no objection to our desiring that all good folk should go to heaven, though there might be some difference of opinion as to who was good enough to be sent there; but the real trouble would begin when the time came for making a start on the journey, because no one could say exactly where and how far heaven is.

The leading article in to-day's issue of your excellent journal may help on the cause of Tariff Reform, but the difficulties in the way of carrying out that which is so dear to the hearts of everyone who is not a consumer may be greater than the Imperial Conference itself can overcome.

There is one fact which is too often forgotten, though it seriously affects trade with our Colonies, viz., that 48,000,000 of people cannot live on the profit to be made out of 12,000,000; and I venture to state a very simple case which may help us to understand what we have to face.

Before the war it was possible to buy for twopence an Austrian pencil of better quality than any English pencil costing threepence; and if we arranged among ourselves that we would prove our patriotism by using nothing but pencils of English or of Colonial make at threepence apiece, what is our position likely to be, as regards pencils, in the world's markets if we cannot undersell the foreigner?

"A STUDENT OF POLITICAL ECONOMY."

February 23, 1917.

[Our correspondent has failed to realise that in addition to Imperial preference, the proposal is to have tariffs as a means of bartering with foreign countries for preferential treatment in international trade. By this means there will be removed barriers set up now against us at the entrance to foreign markets. Now, we, alone among the nations, allow foreigners to make a profit off us without hindrance, hence the starved trades which have made us so dependent upon enemies and so seriously handicapped our supplies when menaced by submarines, &c.—ED. E.]

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Beginning this year, 1917, and continuing until further notice, there will be awarded, at the discretion of the Council of the Institution, in addition to the Graduates' Prize offered each year, a premium of 25*l.* to the graduate who submits the best paper on an appropriate subject in any session. Papers must reach the secretary of the Institution during the month of September in each year, and the award will be made known during Christmas week in each year. This annual premium has been placed at the disposal of the Council by the Daimler Company, Limited. Further information can be obtained from Mr. Basil H. Joy, secretary of the Institution, 28, Victoria-street, Westminster, S.W.

AGRICULTURAL MACHINERY.—In connection with the recent prohibition on the import of agricultural machinery, the Board of Trade announce that the intention is to control the importation in order to ensure that the machinery it is desired to import is of the right type, fulfils the most useful purposes, and is distributed over the country in the districts where it is most required. Applications for licences will be considered by the Department of Import Restrictions, 22, Carlisle-place Westminster, S.W., if previously approved by the Director of Agricultural Machinery Branch, Ministry of Munitions, Hotel Victoria, Northumberland-avenue, W.C., to whom importers should first apply, giving full particulars of the machinery they desire to import. The term agricultural machinery includes any machine, implement, vehicle or other article, or any part thereof, designed or adapted or commonly used for agricultural or dairy purposes.

ENGINEERING SOCIETIES AND THE WAR.—We called to mind the preliminary discussions which took place at the recent meetings in London of the Iron and Steel Institute on the question of extending the scope of the Institute, on reading a paragraph under the above title, contained in *The Canadian Engineer*. Our Canadian contemporary is of opinion that the discussion of business questions should be left to business organisations, the technical society confining itself to scientific discussion. Undoubtedly, adds our contemporary, the view that our scientific societies should lend themselves more generally to the discussion of business matters has been accentuated since the war introduced a new series of economic problems, in the solution of which science will be called upon to play a most important part. If science is to be the ruling factor in the race for national supremacy after the war, it would seem to be probably the wiser course for technical societies to stand by their guns and not permit their energies along the scientific line to be scattered by the introduction of discussions of a totally different character.

TESTS OF COOLERS FOR LUBRICATING OIL.

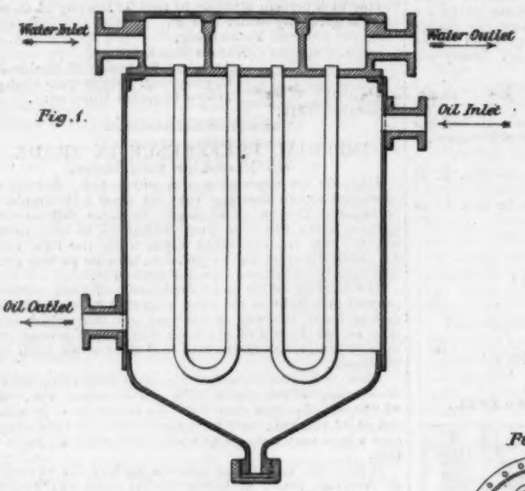


Fig. 1.

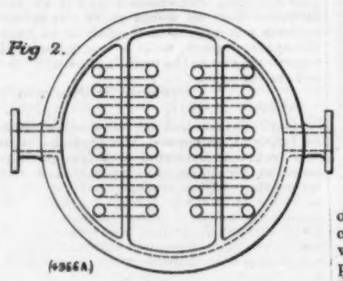


Fig. 2.

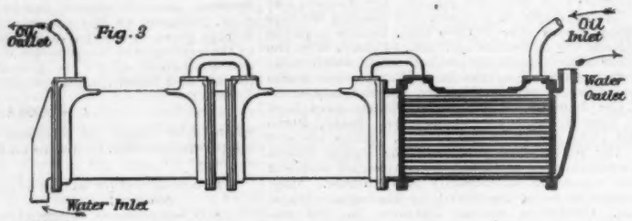


Fig. 3.

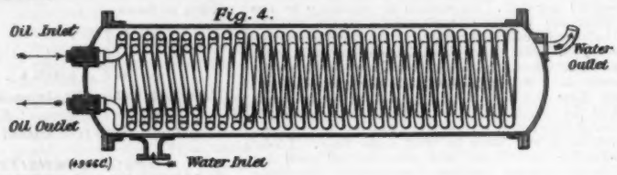


Fig. 4.

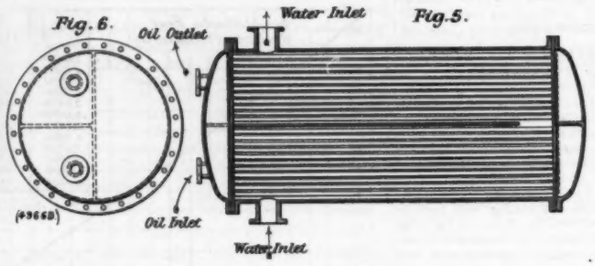


Fig. 5.

Fig. 6.

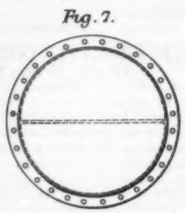


Fig. 7.

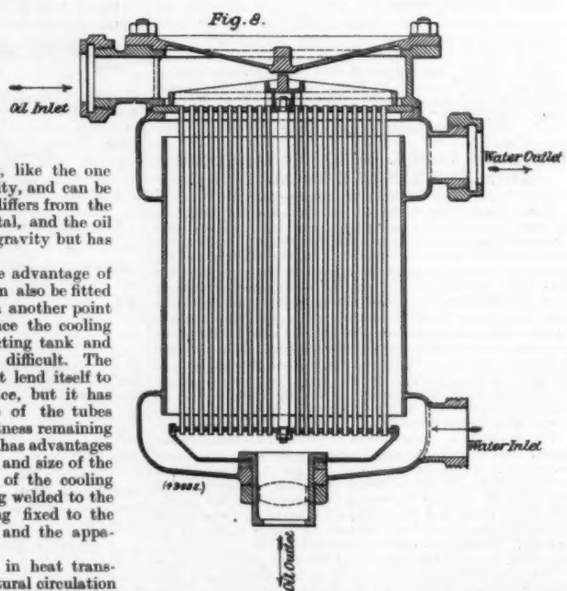


Fig. 8.

In an article contained in the *Rivista Marittima*, Mr M. Boella, of the Italian Corps of Naval Architects, has recently dealt with experiments carried out with several types of coolers for lubricating oil. He states that forced lubrication, which was introduced with high-speed reciprocating engines of the enclosed type, has since been applied extensively to other types of engines, particularly steam turbines and internal combustion engines. Forced lubrication is now in general use also for auxiliary machinery on board ship, and this has led to special attention being given to oil-cooling apparatus.

The efficiency of such apparatus has a great bearing upon the satisfactory working of this method of lubrication. The cooling of oil is surrounded by a few practical difficulties, due to the physical properties of the oil itself. In the case of oil coolers, as in that of all apparatus based upon heat transmission, the fluid to be cooled has to circulate, and to renovate itself, so to speak, by contact with a metallic wall, which is maintained at a low temperature by a flow of water or air. The viscosity of oil increases as the temperature falls, and there arises a tendency to the formation on the metallic wall of a more dense layer of oil, which adheres to it, and is not renewed, thus reducing the efficiency of the apparatus. The cooler must not merely have a sufficient surface, but special attention must be paid to the form of the surface and its arrangement, and to every detail which may contribute to the hastening of heat transmission. Moreover, in the case of oil coolers to be used for naval purposes, the space taken up, weight, continuity of action, and the facilities for inspection and cleaning, are also important conditions which have to be taken into account.

Figs. 1 and 2 show a vertical section and a plan of an oil cooler, the cylindrical receiver of which is generally inserted in the circuit traversed by the lubricating oil. It has a double cover, with partitions which divide the space between the inner and outer wall into three chambers. The cooling surface is formed by a number of tubes bent U-shape and fitted in the inner wall of the cover. Fig. 1 shows how the cooling water and the oil circulate through the apparatus; the latter can be emptied at any time by a valve at the bottom of the receiver.

Another type of oil cooler, which may be considered as an intermediary between those having a natural circulation and those in which circulation is a forced one, is illustrated in Fig. 3. This consists of a nest of small tubes welded at their ends into two tube-plates and contained in a cylindrical drum in which circulates the oil, the water for cooling flowing inside the tubes. A number of such coolers are frequently connected together, as shown in Fig. 3. This oil cooler, like the one in Figs. 1 and 2, is of large capacity, and can be utilised as a collecting tank, but it differs from the first type inasmuch as it is horizontal, and the oil circulation does not take place by gravity but has to be effected by means of a pump.

The coolers of this type have the advantage of not requiring a collector; they can also be fitted inside the oil-collecting tank. From another point of view this is a disadvantage, since the cooling nests of tubes encumber the collecting tank and render inspection and maintenance difficult. The type shown in Figs. 1 and 2 does not lend itself to a large development of cooling surface, but it has the advantage that the U-shape of the tubes allows for free expansion, their tightness remaining unimpaired. The type shown in Fig. 3 has advantages of a different kind; the arrangement and size of the tubes allow for a great extension of the cooling surface, but the straight tubes being welded to the tube-plates, and these latter being fixed to the shell, free expansion is impossible, and the apparatus is liable to get out of order.

Mr. Boella states that efficiency in heat transmission in the coolers having a natural circulation depends upon the regularity with which the oil descends in horizontal strata, this being the greater the slower the flow of the oil. But, on the other hand, the transmission of heat between two fluids through an intervening wall is generally more active the greater the velocity of the fluid in contact with the wall. These two conditions are contradictory, and the effect is to limit the efficiency in heat transmission. In other words, coolers of the type under consideration are either of low efficiency, or else they should have a large cooling surface, when they become heavy and cumbrous, and consequently high in cost. For example, an oil cooler of the type shown in Figs. 1 and 2, forming part of an 8,000-h.p. marine turbine plant and consisting of a receiver 80 cm. (31.5 in.) in diameter and 1 m. (39.4 in.) high, acting at the same time as an oil collector, weighs complete, empty, 350 kg. (772 lb.) and has only 2.60 sq. m. (28 sq. ft.) of cooling surface. The lubrication pumps have a discharge of a little less than 2 litres (0.44 gallon) per second. The efficiency of the cooler is therefore limited and the temperature of the oil remains high; the bearings of the turbine are, moreover, water-cooled. An horizontal cooler of the type shown in Fig. 3, used for cooling the lubricating oil of a marine 850-h.p. internal combustion engine, and consisting of three equal lengths connected in series, 0.350 m. (13.8 in.) in diameter and 2.800 m. (110.3 in.) in length, weighs, complete, empty, 560 kg. (1,234 lb.) and has a total cooling surface of 45 sq. m. (484 sq. ft.). This large cooling surface gives the apparatus a high efficiency; this, however, is obtained at the expense of weight and satisfactory working, since the very great number of tubes it contains (as many as 1,700) is a cause of frequent failures through leakage at the joints of the tubes with the tube-plates.

In the coolers having forced circulation no account is taken of the increase in density which the oil acquires on cooling. Hence, in the first place, the position of the cooler and the direction of the oil flow inside the cooler are of no importance, and, secondly, in order better to govern the oil flow this has to follow a well-determined course, inside rather than outside the cooling tubes. The tendency which the cooling

GUARDS FOR WOOD-WORKING MACHINES.

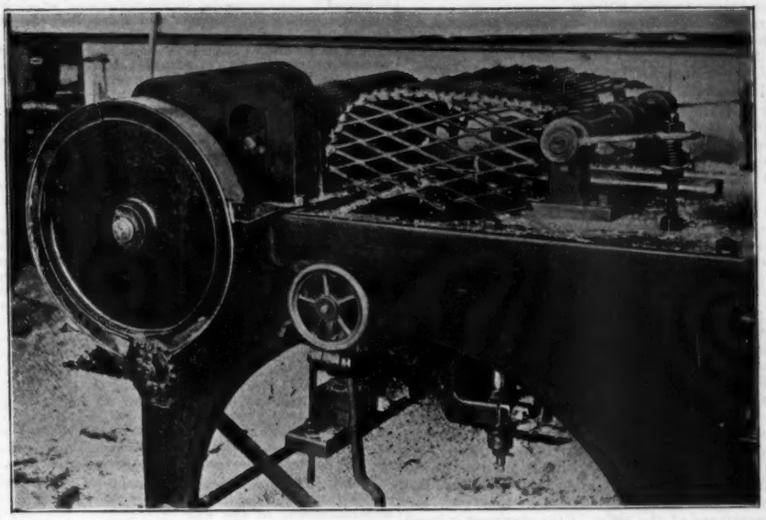


FIG. 7. GUARD FOR PLANING AND GROOVING MACHINE.

FIG. 8. GUARD FOR BAND SAW.

surface has to become inactive, owing to the formation of an inert oil stratum, manifests itself in these coolers, as in those of the preceding type, but for a different cause. A method of overcoming this is to give the oil flow a high speed inside the cooling coils and in compelling it to follow a tortuous path, so that the violence of the current thins the film of oil which adheres to the cooling surface. The cooler illustrated in Fig. 4 answers this purpose; the oil flows through the coil at a speed of 4 m. to 5 m. (13 ft. to 16 ft.) per second. A cooler of this type for an internal-combustion engine of about 800 h.p. occupies a space the length of which is slightly under 3 m. (9 ft. 10 in.) for a diameter of about 40 cm. (15.7 in.), and can transmit 200, and even 250, calories per hour per square metre of cooling surface and per degree Centigrade of difference in temperature between the oil and the cooling water (73 and 92 British thermal units per square foot per degree Fahrenheit). Such a result is a satisfactory one, but the space taken up by the apparatus is not negligible. Further, owing to the high speed of the oil flow and the great length of its path, a high resistance is opposed to the flow, necessitating the maintenance of a high pressure on the pump delivery. This has to be met by increasing the power of the lubricating pump.

theoretically correct, does not give very good results in practice; it does not yield, according to the author of the article referred to, an efficacious lamination of the oil, and an imperfect centring of the retarders gives rise to the formation of paths of least resistance, to which the oil resorts in greater amount. This type of cooler has a most limited efficiency, much below that of the coil cooler, and also below that of coolers with free circulation for an equal cooling surface. A cooler of the type shown in Figs. 5 to 7—styled "condenser type"—for an 8,000-h.p. marine turbine, has an outside diameter of 55 to 60 cm. (about 23 in.) and a length of 1.7 m. (about 5 ft. 6 in.). Its weight, empty, is 700 kg. (1,543 lb.). The delivery of the lubricating pump is 9 tons per hour; the cooling surface amounts to 19 sq. m. (over 204 sq. ft.). The apparatus with difficulty produces a reduction of 6 to 8 deg. C. in the temperature of the oil; the maximum temperature remains in the vicinity of 48 deg. C. (118 deg. F.). In the ordinary conditions of temperature of the circulating water, these results correspond approximately to a coefficient of transmission of 70 calories per hour per square metre of cooling surface and per degree Centigrade difference between the temperature of the oil and that of the water (25 British thermal units per square foot per degree Fahrenheit), a value which is indisputably low. From the point of view of space taken up and weight this type is not superior to the preceding ones, and since it is built throughout of brass its cost is higher.

An improved type of oil cooler is illustrated in Fig. 8; this, adds Mr. Boella, the oil flow is laminated to a high degree by passing through a nest of flattened-down tubes; for this reason it is called a "lamellar cooler." The flat tubes are vertical, they are held in two tube-plates, and are contained in a cylindrical drum in which circulates the cooling water. The tubes are short, thus facilitating manufacture. The upper tube-plate is rigid, whilst the lower one is connected to a movable cover, at the bottom of which is fitted the oil outlet pipe, the arrangement ensuring the free expansion of the tubes and allowing the removal of the whole nest of tubes and its ready replacement by another set. The efficiency of this cooler is much higher than that of the preceding ones; it is obtained with a less cooling surface, and hence for a less weight and less bulk. A small apparatus of this type, weighing 37 kg. (81 lb.), and with a cooling surface of hardly 1.50 sq. m. (about 16 sq. ft.), reduces by about 20 deg. C. the temperature of a current of oil of 2,000 kg. (about 2 tons) per hour, maintaining it at a maximum temperature of 60 deg. C. (140 deg. F.). The flattened tubes also lend themselves well to oil coolers in which the cooling medium is an air current. In these the oil cooler has the form of a circular arc, inside which revolves the ventilator fan.

The annexed table gives a comparison of the various oil coolers tested by Mr. Boella.

The experiments carried out were of a necessity limited in their scope and their results require confirmation; they, however, point to the fact that oil coolers are susceptible of important improvements. The influence which such appliances have upon the satisfactory working of lubricating plants, of which they form an essential part, amply justifies all efforts made to increase their efficiency.

Types of Oil Coolers.	Weight.	Diameter.	Height or Length.	Space taken up.	Cooling Surface.	Weight.	Space taken up.	Coefficient of Transmission. Calories per sq. m. and Cent. degree and B.T.U per sq. ft. per degree Fahr. of difference in Temperature.
	kg. lb.	m. in.	m. in.	cub. m. cub. ft.	sq. m. sq. ft.	Per sq. m. kg. Per sq. ft. lb.	Per sq. m. cub. m. Per sq. ft. c. ft.	
Oil cooler, Figs. 1 and 2	350 = 772	0.800 = 31.5	1.00 = 39.4	0.502 = 17.7	2.60 = 28	135 = 27.6	0.190 = 0.63	90 to 160 = 33 to 59.
Oil cooler, Fig. 3	560 = 1,234	0.350 = 13.8	2.80 = 110.3	0.270 = 9.5	45 = 484	12.5 = 2.56	0.006 = 0.02	—
Oil cooler, Fig. 4	450 = 992	0.400 = 15.7	3.00 = 118.1	0.380 = 13.4	20 = 215	22.5 = 4.61	0.019 = 0.063	180 to 200 = 66 to 73
Oil cooler, Figs. 5 to 7	700 = 1,543	0.600 = 23.6	1.70 = 66.9	0.482 = 17	19 = 204.52	36.8 = 7.54	0.025 = 0.084	70 to 95 = 25 to 35
Oil cooler, Fig. 8 (two elements)	120 = 265	0.320 = 12.6	0.40 = 15.7	0.065 = 2.3	5.76 = 62	20.8 = 4.26	0.011300 = 0.038	370 to 490 = 136 to 180

Another type of cooler having forced circulation frequently used in marine turbine installations is shown in Figs. 5 to 7. This consists of a nest of straight tubes held at the ends in two tube-plates by means of screwed glands and packing, the nest of tubes being contained in a cylindrical drum similar to the drum of a surface condenser. The oil flows inside the tubes, and it has generally a quadruple flow, owing to the action of baffle plates; the cooling water circulates round the tubes, and has a double flow under and over a diametrical partition. The oil flows through the tubes at a moderate speed. The current of oil is mainly confined to a central core, hence it flows through without cooling appreciably. An attempt to remedy this, and to sweep along the film adhering to the cooling surface, consists in placing retarders inside the cooling tubes. These are made of tubes smaller than the cooling tubes; they are closed at their ends, and are provided at regular intervals with transversal pins arranged so as to maintain them in the centre of the cooling tubes. The device, although

GUARDS FOR WOOD-WORKING MACHINERY.

FEW machines of the factory have been more prolific in serious accidents than circular saws. Small saws of 6 to 9-in. diameter lop off joints and finger-tips with the same facility that they cut timber. As a practical sawyer once said: "It is done before you really know what has happened. A sharp cut, a spill of wood, a look at the fingers—and part is gone." Then there is time for reflection. With the high rate of speed at which circular saws revolve, it is no wonder that they do damage so suddenly. The wonder is that the damage is not more severe. There is constant danger in the teeth; and the danger is at a maximum when the teeth are scarcely visible.

The causes of accidents are many and varied. A

workman is pushing timber along to the front of the saw, approaching nearer and nearer, with his hand still on the "stuff." When close to the teeth, he slips, and in an instant the thumb and first finger are lacerated. In another instance the wood is damp and unusually knotty. It sticks to the saw instead of passing forward. Suddenly the wood lifts from the table, and, in his anxiety to save the stuff from flying through the room, the workman instantly thrusts it down towards the table, only to find he has touched the saw. Another piece of wet stuff has to be sawn for a pressing job, and is passed through the saw without wedge or rip-knife at the back. It binds the saw like a vice, and actually stops the saw with the strap on the driving-pulley; then, suddenly, the latent power gains the mastery and flings the board back against the sawyer with a terrible blow. A workman is sawing small rods where he thinks no guard is necessary, when an innocent-looking piece just touches the back edge of the saw. Quick as lightning, it is picked up by the teeth and flung across the shop, where it meets at unawares a fellow-workman. From this cause alone men have suffered fatal injury. Yet another common cause of injury is due to the custom of stopping the revolution of a circular saw. When a piece of work is finished the driving-strap is passed to the loose pulley, and the saw will come to a standstill in two or three minutes. Occasionally the workman endeavours to stop it immediately he has finished his job. He takes a flat rod of about 10 in., and presses it gently against the face of the saw. If all goes well, the saw is brought to a stand in a few seconds. But if this brake-rod touches the teeth it is flung away, and the workman's hand is plunged on the saw. These are common accidents on hand-fed saws, occurring every week in wood-working factories.

On large machine-fed saws—3 to 4 ft. in diameter—the casualties are less frequent, but are more severe. Log-benches are near the floor to facilitate work on tree-trunks and heavy logs without much lifting. If a workman should slip on one of these saws the injury is unspeakable. An extremely dangerous practice in some log-shops is to step over a bench when the saw is revolving. These benches are more or less slippery, and limbs have been amputated by the slip of a shoe-nail. To prevent these casualties, ample and efficient guards are now within the reach of every factory-master; and it is a significant fact that where saw-guards are properly applied, and faithfully used, the accident roll has been reduced.

Saw-Guards.—The first essential of a saw-guard is the rip-knife provided at the back of the saw for the purpose of opening the timber as it leaves the teeth. Most serious accidents, and many fatalities, have resulted from the absence of this rip-knife. And some rip-knives are very inefficient owing to fragile construction. Fig. 1, page 202, shows a strong rip-knife for a 2-ft. saw. This passes into the table slot, and is surmounted by a holder with four slotted wheels, which allow the front guard to rise and fall as required by the varying thicknesses of timber. At the tip of the front guard is a metal roller which rides freely on the timber, and prevents any contact of fingers with the saw. The moment the work is finished the front guard drops nearly to the table and completely shields the saw-teeth. Everywhere these teeth are covered.

In Fig. 2 is shown a saw used for rough logs of hard wood, and the guard must be substantial and extremely well fixed. The rip-knife cannot sway to right or left, and the teeth are covered as far as practicable. The same principle of guarding is applied to saws of smaller diameter, by carefully adjusting the rip-knife with its alignment true to the plane of the saw. In guards for saws of all diameters the crucial requirement is to cover all teeth not actually cutting the timber.

Planing-Machine Cutters.—In most wood-working factories these cutters account for a large proportion of the injuries to workmen. In the two, three, or four-square-block cutter the danger is at its maximum.

A workman is cutting a piece of knotty stuff, when, suddenly, one of the cutters catches the edge of a knot, upsets the piece of wood, and lets the man's hand into the cutting-slot. The result will be obvious. In another instance a man is pushing along a thick piece of wood and is desirous of making a well-finished end. Gentle pressure is applied, the cutters jerk the end from his fingers, and these are severely cut—possibly amputated.

Why are circular cutters so seldom adopted? This form of cutter is illustrated in Fig. 4, where a cutting-knife is being fixed in a block. The block section is circular, and two or three cutters may be inserted, these projecting $\frac{1}{16}$ to $\frac{1}{8}$ of an inch, as desired. With this cutter it is hardly possible to encounter any serious accident. Fingers and hands cannot be mutilated. They cannot be drawn into the slot. The knives can only lacerate the skin to the extent of about $\frac{1}{16}$ of an inch; and, as a rule, the injuries inflicted are merely superficial wounds.

And these may be obviated by the provision of the simple guard shown in Fig. 3, page 202. This guard is held on an upright spindle by the side of the driving shaft of the machine; it may, in a moment, be turned over the cutters to protect the workman's hand from all possible risk. It is an interesting fact that where circular cutters are in use there are seldom any accidents, and these are only trifling.

The square-block cutter is sometimes preferred for its deeper bite into the timber. But this is largely a detail of adjustment. The square-block cutter is admittedly dangerous, and should invariably be guarded securely. The knives should be efficiently covered with the guard extending in front and behind them for at least two inches. The appliance shown in Fig. 5 is telescopic; its parts can be drawn out for any required width of timber when face-planing; and when edging timber the guard can be drawn close to the wood. A small knob A on the top enables the workman to manipulate the parts with every facility. The guard can also be raised or lowered in the guide D by a balance-weight E at the machine face. A planing-machine guard should be simple and absolutely secure. Where it is difficult to handle the workman is apt to discard it.

The panel-planing machine is often the source of accident owing to the roller-feed being unprotected. At times the feed slows down owing to lack of driving power or damp timber. The workman urges on the wood by steady pressure, and his fingers slip between the fluted roller and the timber. One nip is quite enough to grasp the fingers and crush them by $\frac{1}{4}$-in. flutings; and if a workmate be not close at hand to stop the machine, the injury may be irreparable. To prevent this casualty is a very simple matter. Fig. 6 shows an iron rod of oblong section fixed in front of the fluted roller, its lowest edge being in line with the lowest periphery of the roller. If a workman's hand slips on the timber, it is thrown against the guard, and no injury ensues. The fixture costs only a few shillings.

An excellent machine is shown in Fig. 7, page 199, for planing and grooving a piece of timber at one operation. The grooving is accomplished by one or more circular saws fixed on an upright spindle. Without guard, this position of the saws would be extremely dangerous. A guard of expanded metal immediately puts the operation in safety, and it is impossible for a workman's fingers to gain access to the revolving parts. Besides, the meshes are such as to prevent any accumulation of shavings or sawdust.

When Band-Saws Fly.—Every practical sawyer is aware of the perils of a flying band-saw. Good workmen have unfortunately suffered irreparable injuries from this cause. These injuries, curiously enough, come to the *face* of the workman rather than to his hands. As a rule a fearful gash is made on the cheek or side of the head. Band-saws are generally tested, before delivery, to a far greater stress than they are likely to encounter in the factory; but several causes operate to subject the bands to extraordinary tensions. Damp and knotty wood sometimes causes a band-saw to snap suddenly. If, in making a curve, close-grained wood is turned too rapidly, the saw is subjected to excessive stress; it may leave the upper pulley, or snap between the upper and lower pulleys.

It is, therefore, of supreme import that a band-saw should be encased between the pulleys, as, for instance, is shown in Fig 8, page 199, so that, on sudden fracture, it may be held within the casing. The workman's head will be very near, but it will be quite safe. The casing is made of two flat boards A, hinged together and so divided as to allow easy passage of the band. A band is easily changed on opening the casing at the hinges.

The lower pulleys of band-saws are frequently a source of injury to workmen's limbs. Knee-caps have fallen to the spokes of these pulleys. Hands, too, have felt their terrific force. A complete guard can, as shown in Fig. 8, be made of solid boarding B, tongued and grooved, and fixed to the floor. The upper pulley is usually at a safe height, and seldom gives any trouble.

GILL SCHOLARSHIP AND MEMORIAL EXHIBITIONS.—The Secretary of the War Office announces that a limited number of boys may be nominated by the Army Council for admission to a competitive examination for one Gill Memorial Scholarship and two Gill Memorial Exhibitions which will be held at Brighton College in June next. The annual value of a Gill Memorial Scholarship is 50*l.* and that of a Gill Memorial Exhibition is 45*l.*, tenable for three years (the period may be extended to four years on the recommendation of the head master). To be eligible for nomination by the Army Council a candidate must be: (*a*) Under 15 years of age on June 1, 1917, and (*b*) the son of an officer of the Regular Army (serving or retired), Special Reserve or Territorial Force. The preference will, however, be given to sons of officers of the Regular Army. The successful candidates for the scholarship or exhibitions will enter Brighton College at the termination of the summer vacation. Applications for nomination by the Army Council should reach the Secretary, War Office, London, S.W., not later than May 1 next, accompanied by birth certificates and certificates of conduct covering the last two years.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Perhaps at the moment the most interesting feature of the steel industry in the West of Scotland is the increasing demand for steel of all kinds required by the shipbuilders who have been fortunate in securing contracts for new merchant vessels, the Shipping Controller having now got fairly well to work. Acting in conjunction with the Admiralty and the Board of Trade, Sir Joseph P. Maclay has made such arrangements as shall keep the Clyde yards busy for many months to come, so that there is no possible fear of any slacking-off in the steel works, even were the shipping contracts all that had to be depended upon. Orders for quite a number of the standard boats have been placed locally. Everywhere the activity is unparalleled, practically the entire attention of all concerned being concentrated on the material required for war purposes. Shell bars are in continuous request, and the output is perhaps greater now than it has been at any other period during the past 2½ years. With these very pressing demands little steel is available for ordinary mercantile consumers at home, while the only export that is going through is some small lots to the allied Governments. Prices remain practically on the level of last week.

Malleable Iron Trade.—Business in the malleable iron trade continues at the highest possible pressure, Government still is the principal user, directly or indirectly, of the enormous output. As has been the case for some time now, steel is being used for an ever-increasing proportion of the contracts formerly served with iron, so that the output in the steel departments is considerably in excess of that in the iron departments. For export the price of malleable iron remains particularly firm.

Scotch Pig-Iron Trade.—Considering the various difficulties which continue to beset the path of pig-iron manufacturers, in the way of transport facilities and shortage of wagons, it is evidence of the extreme necessities of Government, both direct and indirect, that there is no diminution of the high level of pressure which has distinguished the pig-iron trade for some considerable time now. Hematite, in particular, is in as strong demand as it has been at any time since the outbreak of war, the bulk of the output being absorbed at the local steel works, where vast quantities are being consumed. The scarcity of No. 1 grade foundry iron shows no signs of any readjustment yet. So great is the local demand for pig-iron that export business has fallen to the very lowest ebb. Prices are unaltered over the week.

Sir George Beilby's New Appointments.—Sir George Beilby, F.R.S., Chairman of the Royal Technical College of Glasgow, has had various honours conferred upon him within the past few days. He has been appointed one of the trustees of the Carnegie Trust for the universities of Scotland, and, in proposing him, Principal MacAlister, of the Glasgow University, paid great tribute to Sir George's extensive knowledge of practical science, and referred to one of his other appointments, that in connection with the Ministry of Munitions, for Sir George Beilby is to act as technical adviser to the committee to deal with problems connected with the Scottish shell industry. He has also consented to act as Director of the new Board of Fuel Research, to the deliberations of which he will bring much technical knowledge from past experience.

CHART TABLE "LIT-FROM-BELOW."—Messrs. Kelvin, Bottomley and Baird, Limited, 16 to 20, Cambridge-street, Glasgow, call our attention to this chart table, which is manufactured by them. They state that the lamps are so enclosed in the light box that no stray illumination is thrown in any direction, the effect being as though the chart itself were luminous.

MEMORIAL TO THE LATE PROFESSOR SILVANUS P. THOMPSON, D.Sc., F.R.S.—The council of the Finsbury Technical College Old Students' Association has appointed a committee, consisting of Dr. M. O. Forster, F.R.S., Mr. W. M. Mordey, M.I.E.E., Mr. W. J. Tennant, M.I.Mech.E., and Mr. John E. Raworth, with Mr. E. W. Moss as secretary, to arrange for a memorial to the late Professor Silvanus P. Thompson. Further information can be obtained from Mr. John E. Raworth, 28, Broadway, Queen Anne's Chambers, Westminster, S.W.

ROAD TRANSPORT IN CHINA.—It would take an enormous time to create a road system in China, says *The London and China Telegraph*, but properly devised motor vehicles can be made more or less independent of proper roads. The recent developments of the motor-propelled caterpillar tractor are fresh in the public memory, and no one who has seen what this type of vehicle can do can have any doubts as to its value in a country like China. Motor cars that are to be driven over unmade roads in China require to have three important points very carefully considered: The engine power must be considerably in excess of what would be necessary in driving over what would be called very bad roads in this country, because the friction between the wheels of the caterpillars and the ground will be very heavy. They also require to be very strongly constructed and fitted with springs in such a manner as to relieve the framework, and, in particular, the engine and gearing, from as much of the shocks received in going over the ground as possible. The wheels, or whatever arrangements are employed to support the vehicle and to move it forward, must also be very strong and very flexible, and must adapt themselves to the varying conditions of the ground met with. These conditions are difficult to meet, but they are by no means impossible.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The position has become aggravated by a further shortage of supplies, which is attributed to the greater delay now being taken in the returning of empties to the pits. It is reported to us on good authority that few of the pits in this area have been able to work through continuously, owing to this cause, and the loss of output is made all the more serious by the time taken in delivery. The outlook in the immediate locality has not been improved by the action of the authorities in transporting, with the aid of the military and rolling-stock under the direct control of the military authorities, a large tonnage of coal to London to relieve the great scarcity prevailing there. The general demand for house coal is abnormal, and arrears are gradually mounting up at the pits and depots. Nor is the situation much brighter in the manufacturing section, and works have had to deplete their reserves in order to eke out the inadequate supplies. Gas companies are not able to get the full requirements at one specific time and have to accept repeated deliveries of smaller quantities periodically, thus making it necessary for them to use up all the reserve stocks they have built up. Both the home and export demand for gas fuel is very heavy. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at pit.

Iron and Steel.—Without possessing any arresting factor, the position continues to be full of interest. Engineering works and heavy foundries are exceedingly busy, and the whole of the output is of the utmost national importance. Light foundries are not so well placed, but there is a very real prospect that in the near future they will be more greatly required on State service. Several further additions to electric furnace equipment are being made, but the outstanding need is for current at a cost which will enable it to be used with greater profit commercially than at the present time. Some of the leading manufacturers express the opinion that the City Council, as the owners of the electricity undertaking, will have to adopt a much more reasonable scale of charges if full benefit is to be derived from this newer method of power-plant. The probability is that no great change will be made until after the war, but there is ample evidence that the authorities are alive to the situation. The material market reveals that the supplies of Swedish metals are not now coming to hand, though the stoppage is regarded as only a temporary one, and the large stocks which are held in the country of Swedish iron and steel are being drawn upon for the time being. The stores of Swedish pig in this country are authoritatively stated to be very large, so that the full supplies for munition works, &c., are assured. The market generally is firm, with supplies ample without being too plentiful. Prices, of course, reach the maximum. Wrought-iron scrap of the heavy quality has brought offers at more than 7*l.* per ton during recent buying. Agricultural engineers report that good progress is now being made with the numerous orders in hand. Their position has been manifestly improved by the higher status recent Government orders have given to their work. File makers find that there is no diminution in demand for their products, and output is rapidly being expanded. Makers of safety razor blades are unable to get the necessary material, and there are signs of a famine in this class of article in the near future. Cutlers are finding that the shell discard steel, which is the only quality allowed them, is of no value for the manufacture of articles which require a cutting edge, and amongst the things to be affected by this set of circumstances is the output of blade razors, so that in this direction also there is likely to be a shortage, for the present production is almost entirely wanted for the Army and Navy. Overseas trade is maintaining a good level. The latest indents are for tools of all varieties, files, saws, shovels, picks, steel, cutlery, plate and silver ware.

National Service.—Mr. Neville Chamberlain addressed a large meeting in the city last night, when he expounded his National Service Scheme, and pointed out that many more men would be required for the essential industries. Sheffield, of course, possesses many of these, so that it is improbable that there will be any great diversion of labour from here, unless it be, as the Director-General stated, that skilled men will be wanted to form the nucleus of skilled artisans necessary to open more munition factories. The enrolment for the scheme, by the way, though open to improvement, is not unsatisfactory considering that in this area there is only a limited class to draw upon outside those actually on work of the first importance, and they do not realise that there is a call for them. At all events, Mr. Chamberlain's meeting has cleared the air.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Allocations of Cleveland pig-iron for the month of March are due, and as iron is stated to be fairly plentiful, they are expected to be on quite a liberal scale. Home consumers are so well placed that they are not keen buyers for early delivery, but they are quite prepared to make arrangements for supplies to the end of June, and further forward contracts, subject to any change in fixed maximum quotations, are reported. The demand for Scotland shows some improvement, though consumers of pig-iron north of the Tweed, who used to buy largely in this market, continue to take very considerable supplies of Scotch iron. Export business is better than it has been, but the tonnage situation still causes inconvenience. Large demands from our Allies continue, and there are still occasional inquiries on behalf of neutral countries. For home consumption, and No. 3, No. 4 foundry and No. 4 forge all stand at 87*s.* 6*d.*, and No. 1 is 91*s.* 6*d.*; for despatch to our Allies No. 3 is 97*s.* 6*d.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1, 102*s.* 6*d.*; and for export to neutral countries No. 3 is 105*s.* and upward, and 110*s.* is the minimum quotation for No. 1.

Stock of Cleveland Pig-Iron.—The stock of Cleveland pig-iron in the public warrant stores stands at 2,293 tons, composed of 2,257 tons of No. 3 quality and 36 tons of other kinds of iron deliverable as standard. Since the beginning of February the stock has been reduced by the withdrawal of 455 tons of No. 3.

Hematite Iron.—On the whole the position of the East Coast hematite branch of the staple industry may be regarded as satisfactory. There is no dearth of iron, but there are still difficulties of transit to contend with. Whilst most home consumers are receiving quite adequate supplies, others continue to complain of irregularity in delivery in consequence of the shortage of wagons. Licences for export are less difficult to obtain than they have been, notwithstanding arrears of loadings to make up. Further sales to our Allies are reported. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Shipments of Pig-Iron.—At the time of writing official returns for February are not to hand, but shipments of pig-iron from the port of Middlesbrough during the second month of the year will probably have approached 50,000 tons, of which a very large proportion has gone to France. Loadings for the previous month were officially given at 35,629 tons, and clearances for February last year amounted to 50,674 tons.

Coke.—Coke keeps in very good demand for local consumption, and for the descriptions required the fixed maximum prices that have ruled for some time past are still being paid. Thus average blast-furnace kinds realise 28*s.* at the ovens, and 30*s.* 6*d.* at the ovens is named for low phosphorus qualities.

Imports of Foreign Ore.—Imports of foreign ore to the Tees continue on a considerable scale. Unloadings at the port of Middlesbrough during February reached round about 145,000 tons.

Manufactured Iron and Steel.—Producers of finished iron and steel are still steadily increasing their already enormous output, and despite claims for manufacture of other descriptions, the making of mercantile shipbuilding material is still growing. Prices all round are strong. To home customers common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (tapered), 14*l.* 5*s.*; packing iron and steel (parallel), 12*l.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

NOTES FROM THE SOUTH-WEST.

Coal Markets.—The coal markets are unimproved, and remain in a dull and listless condition. The requirements of the authorities are insufficient to absorb colliery outputs, and the scarcity of shipping is as acute as ever. In the anthracite district the position is particularly bad, as is evidenced by the fact that in the 41 days ended February 10, 46 collieries have had 516¼ idle days. The new rates offered to neutral vessels have not attracted tonnage, and the inquiry is negligible. Stocks of all coals have accumulated, and buyers with ready tonnage can secure supplies on practically their own terms. Second Admiralty, Black Vein, Western Valley, and best Eastern Valley, large, are all securable from 24*s.* to 24*s.* 6*d.*, and other Easterns range from 21*s.* to 23*s.* 6*d.* Best dry, large, is worth no more than 24*s.*, with the cheaper descriptions from 22*s.* The demand for bituminous coals for export is extremely slow, and No. 2 Rhondda, large, is nominally worth no more than 22*s.* 6*d.*, throughs 18*s.*, and smalls 14*s.* 6*d.* Small steams are in abundant supply, and shippers of large are in many instances required to take a certain proportion of small. Best bunker smalls are weak at 15*s.*, ordinaries 14*s.*, good cargo sorts 12*s.* 6*d.*, and inferiors from 8*s.* 6*d.* Coke is generally steady, as the inland and allied requirements absorb practically the whole of the make. Ordinary foundry is round 55*s.* for export, while the price for France is fixed at a maximum of 47*s.* 6*d.* There is little inquiry for patent fuel, and for quick delivery supplies are obtainable from 27*s.* 6*d.* Pitwood is very scarce and virtually unobtainable, and prices are firm at 75*s.* The Home Grown Timber Committee has given the matter of pitwood supplies serious consideration, for it is now reported that the question has been discussed in London, and a committee of colliery owners and of the Timber Committee has been appointed to consider the whole question of endeavouring to supply labour from the collieries for the purpose of felling native timber. A tentative agreement between representatives of Welsh coalowners and workmen has already been made, and a meeting of the South Wales Miners' Federation Council is being convened to deal with the matter.

Shipping Merge.—Shareholders in the Rosella Steamship Company, Limited, and the Scarisbrick Steamship Company, Limited, both of which are managed by Elvidge and Morgan, Cardiff, have agreed to a scheme whereby the former company will be voluntarily wound up and the capital of the latter company increased from 50,000*l.* to 100,000*l.*, and that the shareholders in the Rosella Company shall receive, free of cost, one fully-paid 1*l.* share in the Scarisbrick Company for every share held in the Rosella Company. Both companies have a capital of 50,000*l.* in 1*l.* fully-paid shares. The Rosella Company owns the steamer Monkstone, 5,300 tons d.w., and the Scarisbrick Company the steamer Daybreak, 5,500 tons d.w. The average dividend of each concern has been 18 per cent. in the past four years.

Metal Trades after the War.—A committee of the Swansea Chamber of Commerce has considered the commercial and industrial policy after the war, also what industries are essential to the future safety of the nation, and what steps should be taken to maintain or establish them. Referring to the spelter and allied trades, the committee points out that in view of the great demand for galvanised iron and allied products which is likely to arise after the war, and to continue for some years, it will be necessary to assure their works an ample supply from the resources of the Empire and allied countries of all classes of raw material used in the manufacture of spelter. In order to provide for this, it is suggested that all zinc and calamine iron and all zinc concentrates produced should only be supplied to British and allied manufacturers of spelter.

Penarth Dock Trade.—Exports and imports in 1916 amounted to 3,393,889 tons, against 3,329,257 tons in 1915. Exports alone totalled 3,223,561 tons, compared with 3,153,461 tons, of which coal and coke accounted for 3,219,532 tons against 3,145,957 tons. Imports amounted to 170,328 tons, against 175,796 tons; 2,550 vessels of 1,563,114 registered tonnage cleared, compared with 2,607 of 1,575,183 tons in 1915.

Finance.—North's Navigation Collieries (1889), Limited, have declared an actual and final dividend of 10 per cent., making, with the interim dividend of 5 per cent. already paid, and also a bonus of 5 per cent., a total distribution of 20 per cent. against 12½ per cent. in 1915.—Great Western Colliery Company, Limited, recommends a dividend of 10*s.* per share on preference shares of Class A, 15*s.* per share on ordinary shares of Class B, fully paid, and 12*s.* per share on ordinary shares of Class B, partly paid, less income tax, making 20 per cent. for the year against 15 per cent. in 1915.—The Celtic Collieries, Limited, made a profit in 1916, after deducting interest on debentures and loans, and providing for excess profits duty, of 34,531*l.*, and the dividend is equal to 10 per cent. for the year.—The Powell Duffryn Steam Coal Company, Limited, made a profit in 1916, after allowance for excess profits duty, writing off depreciation, &c., of 475,461*l.*, and recommend a dividend equal to 20 per cent. for the year. The output of coal from the company's collieries was 3,659,016 tons.—The Imperial Navigation Company, Limited, made a net profit in 1916, after providing for excess profits duty and income tax, of 25,636*l.*, and the dividend for the year is 20 per cent. (less tax), against 10 per cent. in 1915.

SHIPBUILDING IN THE UNITED STATES.—The Bureau of Navigation at Washington reports that there were in progress or on order in United States shipyards at the beginning of the year 682 vessels, of 2,098,761 tons. Of these 403, of 1,495,601 tons gross, were steel merchant vessels; 161, of 207,623 tons gross, wooden merchant vessels; and 118, of 395,537 tons displacement, war craft. The tonnage of 61 submarines which are in progress is not included.

PROHIBITED EXPORTS.—The Supplement to the *Board of Trade Journal* of March 1 contains complete lists of articles which, according to the latest information received by the Board of Trade, are prohibited to be exported from Denmark, France (including Algeria), Italy, Japan and the Netherlands. The Supplement also contains a list of articles (complete to date) which are prohibited to be exported from the United Kingdom. Copies may be obtained at a cost of 3*d.* each (3½*d.* post free) through any bookseller, or directly from H.M. Stationery Office, Imperial House, Kingsway, London, W.C.

ROYAL NAVY—SPECIAL ENTRY NAVAL CADETSHIPS.—About 50 Cadetships (Special Entry) will be offered for competition at the examination to be held by the Civil Service Commissioners conjointly with the Army Entrance Examination for Woolwich and Sandhurst, commencing July 3 next. Candidates are required to be not more than 18½ nor less than 17½ on June 1, 1917. Candidates who competed unsuccessfully at the examination in February, 1917, and are still eligible as regards age, will be allowed a further opportunity to compete. Candidates who have served with His Majesty's Naval or Military Forces during the war will be allowed a deduction from actual age in respect of such service. To receive this concession candidates must furnish an official certificate as to the period of their service. The syllabus of subjects of examination and further particulars may be obtained from the Secretary of the Admiralty, Whitehall, S.W. Forms of application to be filled in by the parents or guardians of candidates will be furnished on application by letter addressed to the Secretary of the Admiralty. The forms should be completed and returned to the Secretary of the Admiralty not later than the 1st April, 1917.

GUARDS FOR WOOD-WORKING MACHINERY.

(*For Description, see Page* 190.)

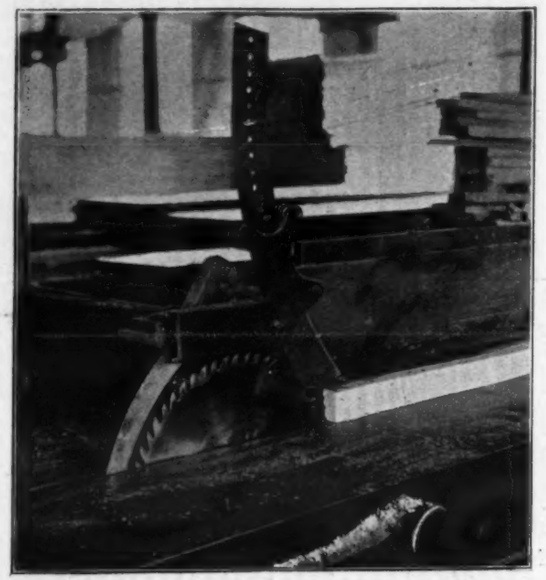


FIG. 1. GUARD AND RIP KNIFE FOR CIRCULAR SAW.

FIG. 2. RIP KNIFE FOR CIRCULAR SAW.

FIG. 3. GUARD FOR PLANING CUTTER.

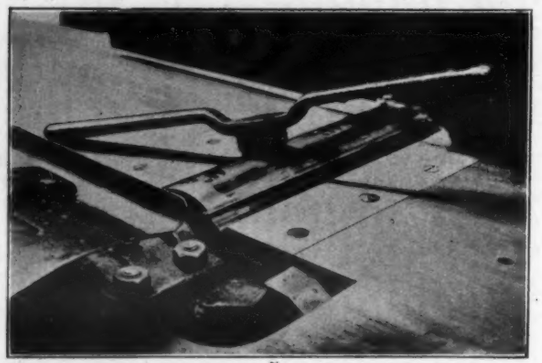


FIG. 4. CIRCULAR CUTTER BLOCK.

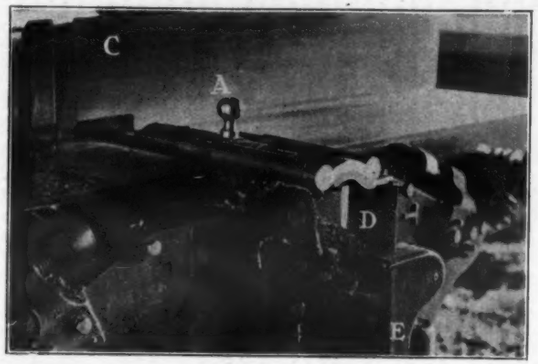


FIG. 5. TELESCOPIC GUARD FOR CUTTERS.

FIG. 6. FEED ROLLER GUARD FOR PLANING MACHINE.

TELPHER INSTALLATION AT THE DALMARNOCK GAS WORKS, GLASGOW.

MR. ALEXANDER WILSON, M.INST.C.E., ENGINEER TO THE GLASGOW CORPORATION GAS DEPARTMENT; MESSRS. STRACHAN AND HENSHAW, LIMITED, BRISTOL, CONTRACTORS.

(*For Description, see Page* 193.)

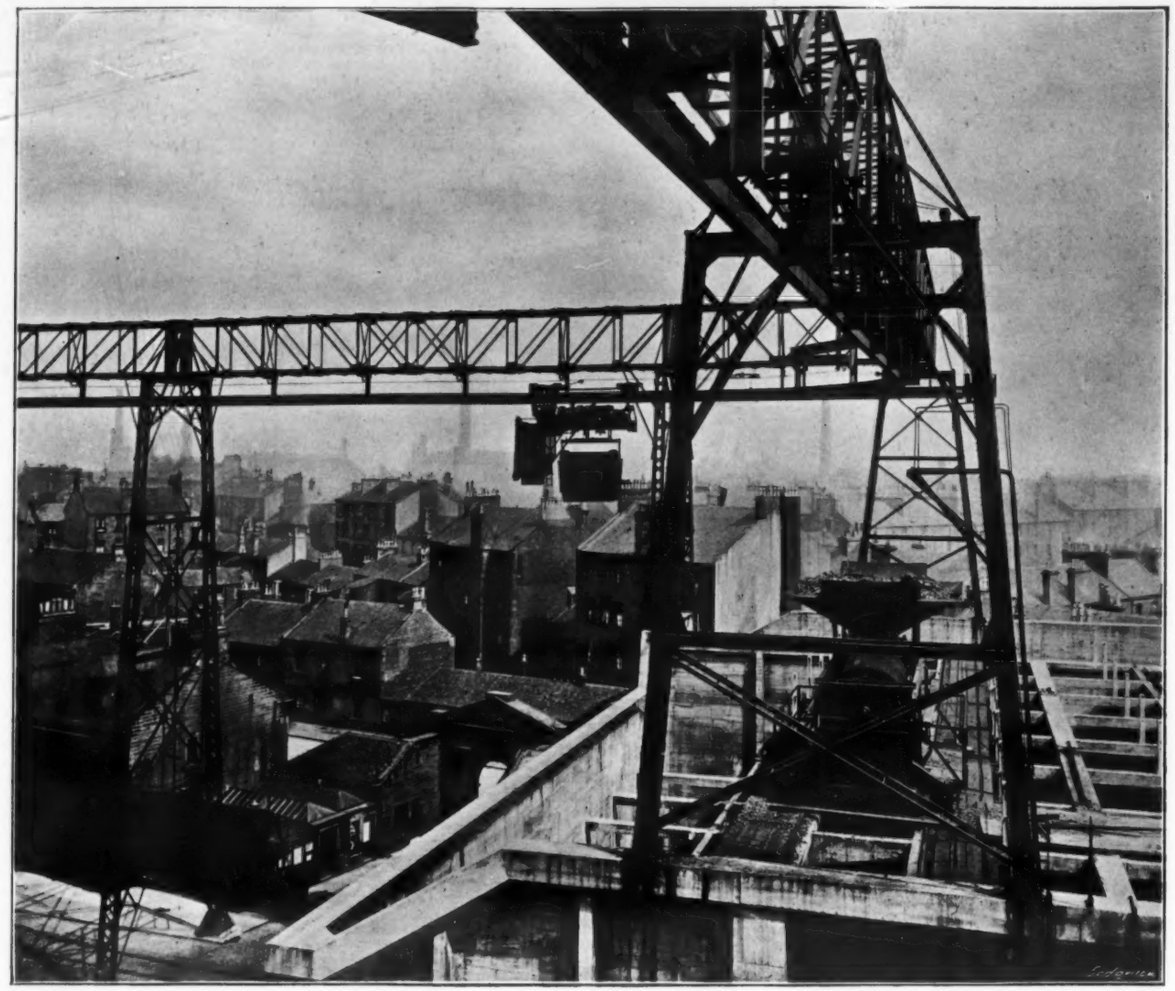


Fig. 35. General View of Telpher Line over Coke Bunkers.

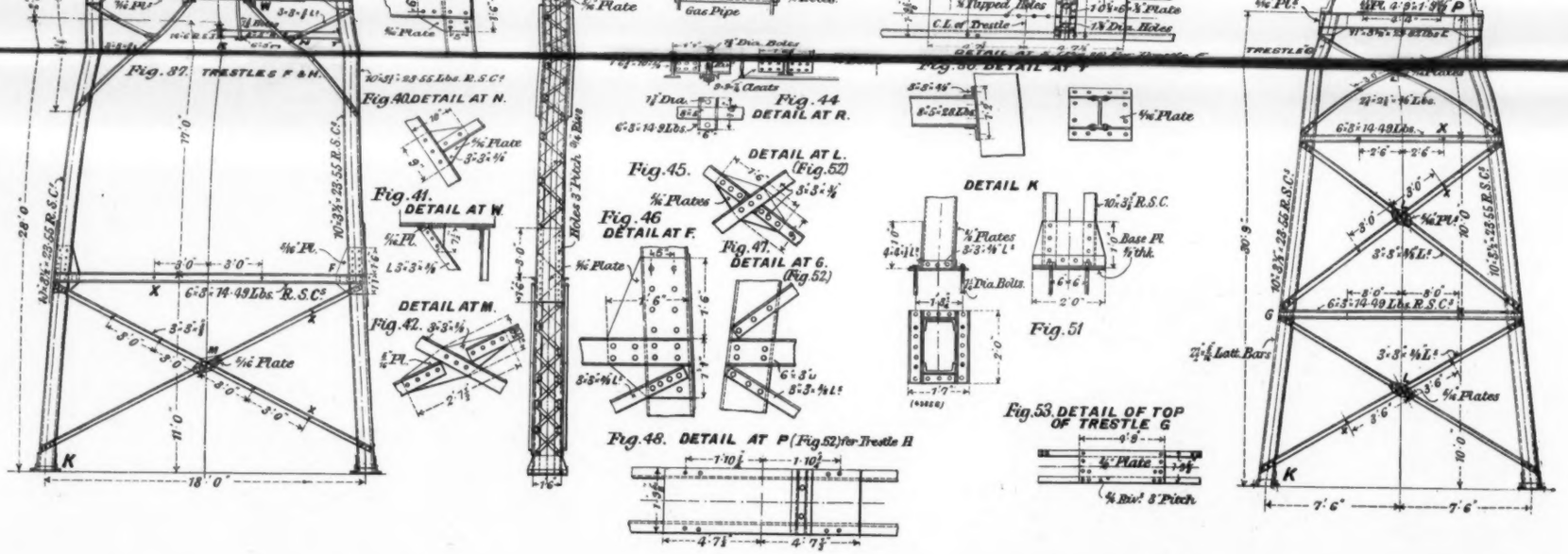


Fig. 37. TRESTLE G F & H.
Fig. 40 DETAIL AT N.
Fig. 41. DETAIL AT W.
DETAIL AT M.
Fig. 42.
Fig. 44 DETAIL AT R.
Fig. 45. DETAIL AT L. (Fig. 52)
Fig. 46 DETAIL AT F.
Fig. 47. DETAIL AT 6. (Fig. 52)
Fig. 48. DETAIL AT P (Fig. 52) for Trestle H
Fig. 50. DETAIL AT Y
DETAIL K
Fig. 51
Fig. 53. DETAIL OF TOP OF TRESTLE G
TRESTLE G

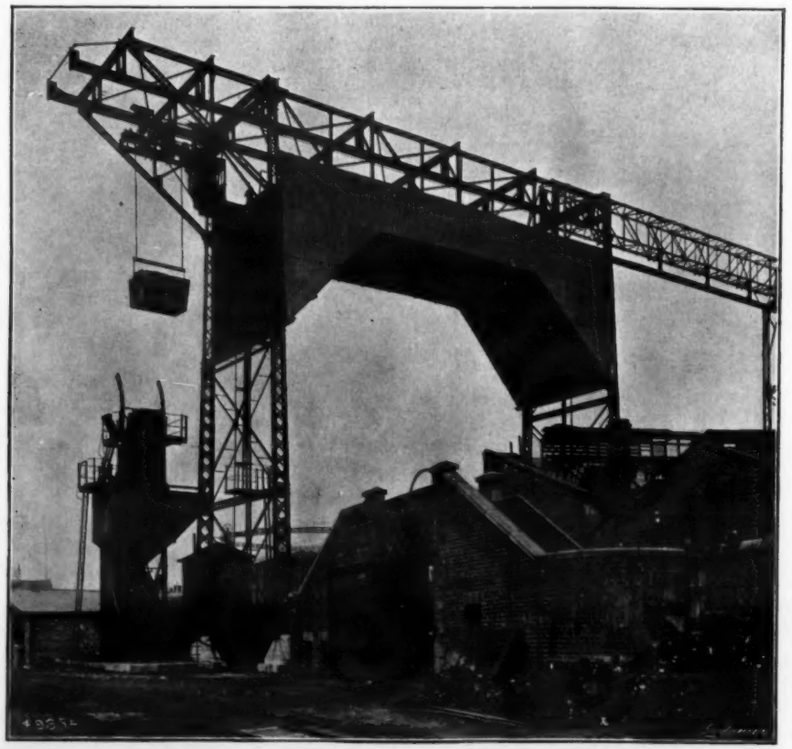


Fig. 54. General View of Skip-Filling Arrangements.

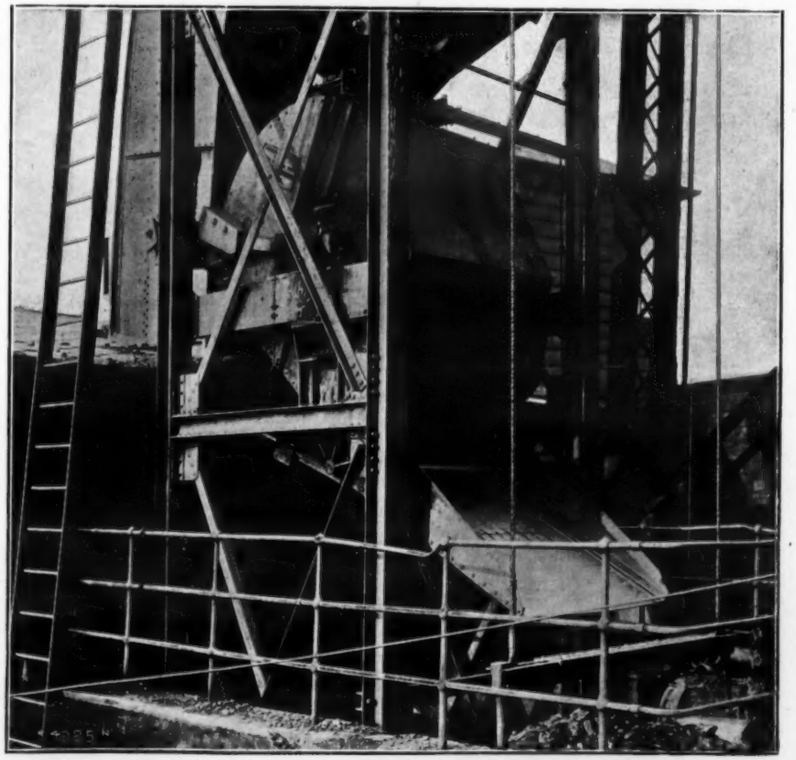


Fig. 55. Automatic Revolving Skip-Filler.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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Thick ,, ...	£2	5	0
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Thin paper copies	£2	5	0
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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 3506 GERRARD.

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NOTICES OF MEETINGS.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, March 3, at the Institute, Wolverhampton Street, Dudley. Mr. J. W. Hall, Past-President, will read a synopsis of his paper on "The Life and Work of Joseph Hall."

THE SOCIETY OF ENGINEERS.—Monday, March 5, at 5.30 p.m., in the apartments of the Geological Society, Burlington House, Piccadilly, W. A paper entitled "High Tensile Steel *versus* Mild Steel for Reinforced Concrete" will be read by Mr. Arthur W. C. Shelf.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Tuesday, March 6, at 2.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment. A paper on "Automatic Signalling" will be read by Mr. C. H. Ellison, and, if time permits, discussed.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, March 6, at 7 p.m. Subject:—"Cast Iron," by a Member.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 6, at 5.30 p.m. Paper to be submitted for discussion:—"The Commercial Metering of Air, Gas, and Steam," by Mr. John Lawrence Hodgson, B.Sc., Assoc.M.Inst.C.E. And ballot for new members.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, March 7, at 8 p.m., at the Royal Institution, Colquitt Street, when a paper will be read by Professor S. W. Perrott, B.A., M.A.I. (Dublin), M.Inst.C.E., entitled "Some Problems of Railway Curves."

THE AERONAUTICAL SOCIETY OF GREAT BRITAIN.—Wednesday, March 7, at the Royal Society of Arts, John Street, Adelphi. Captain T. I. Tizard, R.F.C. Testing Squadron, will lecture on "Methods of Measuring Aircraft Performances."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 8, at 8 p.m. "The Voltage Regulation of Rotary Converters," by Mr. G. A. Juhlin, Member.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, March 8, at 3 p.m., at the Danum Hotel, Doncaster. The following paper will be read:—"The Cementation Process for Mines," by Mr. T. Blandford, B.Sc. The following papers will be open for discussion:—(1) "The Rectification of Benzol," by Mr. W. Newton Drew. (2) "Some Causes of Decay of Mining Timber," by Mr. J. Mitchell.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 9, at 5.30 p.m. A discourse will be delivered by Sir Almroth Wright, C.B., Sc.D., M.D., F.R.S. The subject is "The Treatment of Wounds in War." Afternoon lectures next week at 3 p.m. Tuesday, March 6. Professor W. E. Dalby, M.A., B.Sc., F.R.S., Professor of Engineering, Imperial College of Science and Technology, London, on "Internal Combustion Engines" (Lecture II). Thursday, March 8. Professor Arthur Dendy, D.Sc., F.R.S., Professor of Zoology in the University of London, on "Sponges: a Study in Evolutionary Biology" (Lecture I). Saturday, March 10. Dr. Caleb W. Saleeby, M.D., F.R.S.E., "Imperial Eugenics—Saving the Soldier" (Lecture I).

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Saturday, March 10, at 2.30 p.m., at Caxton Hall, Westminster. A paper will be read on "Indian Railway Carriage and Wagon Rolling-Stock," by Mr. H. Kelway Bamber, M.V.O., Vice-President."

THE CERAMIC SOCIETY.—Saturday, March 10, at 7 p.m., at the Central Schools of Science and Technology. Papers will be read by Mr. John Eyre, R.B.A., Hon. R.C.A., London, on "The Necessity for the Application of Science and Art in Modern Pottery Manufacture," and Dr. J. W. Mellor, on "Do Fireclays contain Halloysite or Clayite?"

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase will date from and include the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, MARCH 2, 1917.

THE VALUE OF BRITISH CANALS.

BY an order made under the Defence of the Realm Act on the 16th ult. the Board of Trade took over yesterday the administration of most of the British canals. The control will be vested in a committee, of which the chairman is Sir Maurice Fitzmaurice, C.M.G., and which numbers amongst its members Mr. I. T. Williams, chief goods manager of the London and North Western Railway Company, and Mr. A. J. Saner, chief engineer of the River Weaver Navigation. The intention of this measure is to give some relief to the present state of affairs on the railways. Few of these have parted to the Colours with less than one-sixth of their normal staff, and the work has had to be carried on by the residue, with such assistance from female labour as has been practicable. The intensity of the traffic has everywhere been far in excess of all peace-time records. In most cases this is true even when the naval and military traffic is excluded. Moreover, as the recent revision of fares has brought home to all, the companies have also been called upon to supply in quantity locomotives, rolling-stock and track for service in France, and further requisitions of this nature are anticipated during the year. Finally, neither labour nor materials have been available for the maintenance of the lines to the old standards of excellence.

The advisability of making the most of our existing waterways to reduce the strain is sufficiently obvious, and it will be of interest to note what measure of relief may prove practicable. Probably it will be comparatively small, mainly because the capacity of an ordinary barge canal for handling goods traffic is inconsiderable when compared with that of a railway. At a recent meeting in support of the Channel Tunnel project, M. Sartiaux, of the Chemin de Fer du Nord, was quoted as stating that at a pinch it would be possible to transport 30,000 tons per day over one of the two tracks which the tunnel is to accommodate. Confirmation of this estimate is to be found in the actual figures recorded for the Bessemer and Lake Erie Railroad, which was constructed mainly for the carriage of ore from Conneaut Harbour on Lake Erie to Bessemer, but also conveys incidentally a considerable passenger traffic. The line is about 230 miles long, and in 1910, at which date there were still some sections of single track, over 14,000,000 tons of freight were handled, in addition to the passenger traffic. Since there is a large return traffic of empty ore cars, the actual tonnage conveyed over a single track cannot have been short of, and may have exceeded, an average of 25,000 tons per day. No ordinary barge canal could handle more than a small fraction of such traffic. The relative inefficiency of canals as means of transport is further indicated by the fact that whilst the railways of the country have an aggregate length equal to about six times the aggregate length of canals, they carry in normal times about fourteen times as much coal, although this commodity is one which is generally held to be particularly well adapted to transportation by water.

It is often asserted that the railway companies in the early days strangled the canals by buying up important links and allowing them to go derelict, or by abusing in other ways the control they then acquired. The Royal Commission on Inland Waterways reported, however, that it could not, broadly speaking, be said that the canals belonging to railway companies were worse maintained than those controlled by local authorities or independent companies.

The common claim for the cheapness of water carriage along artificial canals is of relatively recent origin. When the canals had uncontrolled possession of the field the rates per ton-mile were seldom or ever less than 2*d.*, and generally much more. The rate between Liverpool and Manchester by canal was 6*s.* per ton in the pre-railway era, although this canal had been well engineered by Brindley, and could, accordingly, be operated very cheaply. When railways were first introduced they found in possession of the field extremely wealthy corporations owning the canals, paying dividends of 20 per cent. or upwards. That so many of these prosperous undertakings preferred to sell out to railways rather than to try to compete with them shows that their directors had a much clearer notion as to the relative advantages of the two systems of transport than most of our modern advocates of a vast expenditure on inland waterways. Indeed, the Duke of Bridgewater is said to have himself expressed serious apprehensions as to the ultimate effect on his enterprise of "these d——d trainways," although the triumph of the Rocket lay still deep in the womb of the future.

The late Senator Hill once stated that were he permitted to build a railway for freight traffic only, he would engage to bankrupt any possible canal competition. That this expression of opinion was no vain boast is pretty clearly shown by the freight charges on the Bessemer and Lake Erie Railroad, which, as we have already stated, is pre-eminently a line designed for freight traffic. Some years ago, when an attempt was made to secure public support for a scheme for dockising the Thames, figures were quoted as to the average cost of freight transport by the ordinary Thames barges. These ply on a natural waterway and under exceptionally favour-

able conditions. The average rate was said to be about ½*d.* per ton-mile. On the Bessemer and Lake Erie Railroad the receipts per ton-mile in 1910 were, however, only 0·229*d.* per ton-mile, the working expenses being 0·133*d.* per ton-mile. With such rates artificial waterways can only compete in very exceptional conditions. In France, where the natural navigable channels are much more important than here, the railway companies are compelled to allow the canals a differential of 5 per cent. on traffic between competitive points. The necessity for this discrimination is the more striking since all the waterways are toll-free, so that in point of fact (as in Belgium) the public treasury pays some 40 per cent. of the true freight charges. This state of affairs is essentially that which advocates of a large expenditure on barge canals wish to establish here. They desire that a large proportion of the true cost of transport shall be borne by public funds. In certain circumstances no doubt such a policy may, on the whole, be advantageous, as was recognised when highway tolls were abolished. Roads had, however, to be maintained and extended in any case. It is, however, a much more serious proposition to spend large amounts of public money in extensive developments of a method of transport which even its advocates admit is unable on its merits to compete on equal terms with rival systems which in normal times can handle all the traffic offering.

Even in Germany there is said to be a loss of 1,500,000*l.* per annum on the operation of the artificial canals. On the whole, however, the latter are in this case probably indirectly profitable, since the country being particularly well endowed with natural navigable waterways, relatively short artificial connecting links make these natural channels available for traffic which would otherwise have to seek an alternative route.

In this country the conditions are far from favourable to the construction of artificial canals. We have few large level areas, so that, on the average, a lock is required for about every mile of open channel. In the more favourable conditions in France the length of an canal averages some 20 per cent, more than that of the railway between the same termini, since gradients being inadmissible, the natural contours of the country must be followed very closely. Conditions here being less favourable, the excess length of the canal would probably be substantially greater than in France. Another drawback to a canal lies in the fact that unless a factory is situated actually on its margin terminal charges are much higher than where delivery by rail is possible. A railway siding can be run up any reasonable gradient, and wagons for many classes of goods can be emptied by tipping, at a minimum expenditure of time and money. It is true that special barges have been constructed for the Goole trade which are lifted and tipped, but heavy and costly plant is necessary.

In view of these factors it is extremely improbable that the new committee of control will do much to extend the length of our internal waterways, and the hopes which have been aroused in certain quarters are pretty certain to be disappointed. It may, however, be found possible to ameliorate the existing canal services by improving the connecting links between different systems, and any transfer of traffic from rail to water which can be effected at the present time is to be welcomed, even should it be indefensible from the standpoint of pure economics.

MINOR DIFFICULTIES IN AIRCRAFT MANUFACTURE.

In ordinary engineering work experience has, in most cases, clearly shown which are the most satisfactory materials for any particular service; but trouble is by no means uncommon when working conditions are changed, or when new requirements have to be met. The gradual development of any new branch of engineering usually enables the best materials to be selected by the rather slow process of trial and error, aided, of course, by scientific investigation and by the accumulation of knowledge of the properties of materials in general. In the motor-car industry, for instance, most of the early difficulties encountered in the selection of materials for construction have been overcome in this way. Progress along similar lines had also been made in aircraft manufacture before the outbreak of war, but since then the demand for efficient and reliable aircraft has been such that the experience which would perhaps have taken ten years to gain in normal times has been acquired in two. Science has also been applied to the problems involved to a far greater extent than would otherwise have been the case.

The materials used for aircraft manufacture were dealt with in a very interesting and instructive lecture delivered on the 21st ult. to the members of the Aeronautical Society by Captain G. S. Walpole, D.Sc., A.I.D. The lecturer, however, confined his attention to those non-metallic materials the properties of which are affected by age and by exposure to the atmosphere, so that it is difficult to ensure satisfactory results in service. Of such materials one of the most important is rubber, which is used on aeroplanes for tyres and shock absorbers. Many of the difficulties experienced with this substance were due, the lecturer said, to the fact that rubber manufacturers were not made aware of the functions to be fulfilled by the rubber, and, consequently, the quality supplied was quite unsuitable. In some cases, however, the design was such that no kind of rubber could possibly fulfil requirements. As an instance of this he mentioned a form of shock absorber made up of stout rubber rings stretched over two fixed pins and having the third, or movable, pin in line with the other two but bearing on the outer surface of the ring. With this arrangement the rings soon failed at the point of contact of the movable pin, as might have been anticipated had more attention been paid to the design. A much more satisfactory form of shock absorber, the lecturer said, was a hank of braided rubber cord, known as "exerciser cord." Each cord was composed of, say, 100 strands of pure rubber, to which the braiding was applied under tension. In this form a given amount of energy could be absorbed with a much smaller extension than was the case with unbraided rubber. This fact was clearly shown by means of hysteresis diagrams thrown on to the screen.

A considerable part of the landing shocks on aeroplanes, Captain Walpole said, was absorbed by the chassis-wheel tyres, and as lateral stresses, as well as radial shocks, were encountered in landing, special precautions had to be taken to prevent the tyres from being wrenched off the wheels. Palmer cord tyres had given efficient service for this purpose, and the lecturer therefore illustrated and described the design and method of manufacturing these very important accessories The tyres are very light, so much so that the outer cover will almost float in water, and with the proper air pressure of 50 lb. per square inch they are uninjured by any load that can be carried by the wheel. In a test of one of these tyres, measuring 800 by 150 mm., the load was increased by steps of 1 ton to 5 tons 11 cwt., when the wheel failed by the spokes pulling out of the hub; no damage was done to the tyre. Another important feature illustrated by the lecturer was the fact that owing to the special design of the rim and beading the tyre cannot roll off the rim under a lateral load.

In spite of its many valuable properties, the lecturer continued, rubber was not an ideal substance. As usually supplied it was badly affected by extreme temperatures, and also by oil, petrol, &c. Much, however, could be done by selecting a suitable mixture, and of several different specimens shown immersed in petrol, some were almost completely dissolved, others partially so, and some apparently quite unaffected; the latter quality had been successfully used in the form of tubes for conveying petrol. In one specimen an excess of sulphur had been used in vulcanising—a fact which was apparent by the deposition of sulphur crystals on the surface of the rubber.

Glue and methods of glueing were next referred to by the lecturer, who had investigated the matter in connection with the manufacture of air screws. As a simple theory, he said, it might be considered that the two surfaces to be united by means of glue were covered with a number of dovetailed recesses, which in a perfect joint were completely filled with glue, and the glue would also form a continuous film between the two surfaces. In a bad joint some of the recesses would be empty, others only partially filled, and the film of glue between the surfaces would be discontinuous. That an actual glued joint is really somewhat of this character was clearly shown by micro-photographs of joints in mahogany and walnut, in which it could be seen that the glue penetrates into the pores of the wood for some little distance on both sides of the joint. A large number of tests had been made by the lecturer, who is a member of the Aeronautical Inspection Department, and by his colleagues at the Royal Aircraft Factory, in order to ascertain what effect the conditions under which joints were made had on their strength. From the results of these tests they were satisfied that it was not good to hurry unduly the clamping of the work after glueing, and that the best joints were made in a warm shop with warmed timber. Within a limited range, using a good skin glue, the degree of concentration of the glue used appeared to have no effect on the strength of the joint—probably because the thinner and weaker glue penetrated farther into the wood, and *vice versa*.

Another matter that appears to have been investigated very thoroughly is the properties of "dopes," which are employed to tighten up the fabric of aeroplane wings and other parts, after it has been stretched on to the structure. It was not easy, Captain Walpole pointed out, to meet all requirements in this direction. The fabric must be drawn up tight enough to prevent all sagging, but not enough to buckle the structure, and the tightness should not be affected by atmospheric conditions or oil. At the same time the materials used must be as light as possible, must not harm the fabric, and must be inexpensive and easily procurable even in war-time. Generally speaking, dopes were composed of a film-forming material dissolved in a suitable solvent, with the addition of other ingredients to render the film flexible, fireproof and waterproof. The most satisfactory film-forming agent, the lecturer said, was acetyl cellulose, and a typical dope might be made with 7.5 per cent. of this substance dissolved in 88.5 per cent. of acetone, with the addition of 1 per cent. of triphenyl phosphate and 3 per cent. of benzyl alcohol. The function of the latter material was to soften the film, and that of the triphenyl phosphate to render it waterproof. With regard to the conditions affecting the tautness of a finished plane it appeared that the tautness increased with the number of coats applied up to a certain point, after which additional coats had but little effect. It had also been found that the final tautness was independent of the viscosity of the dope as applied, and also of the extent to which the fabric was stretched in covering the plane; it was, however, considerably affected by the twist of the yarn and the closeness of weaving. It was interesting to note that some of the difficulties experienced with dopes had been traced to the small amount of grease used in lubricating the shuttles in weaving. This grease caused the dope film to pass right through the fabric to the other side, from which it was separated by a large number of air bubbles, so that it could easily be stripped off. The addition of a much greater percentage of acetone to the dope was found to give better results under these conditions, but the trouble could be completely avoided by washing the fabric and thus removing all traces of grease. With cotton fabric the process of doping appeared to be a complete failure, as it was impossible to obtain the requisite degree of tautness and the film quickly broke up. This was probably due to the fact that cotton fibres were of a different character from the flax fibres of linen fabric, though the exact reason was not yet understood.

In comparing the results obtained under different conditions an instrument known as a tension-meter was used. This consists of a brass disc, about 6 in. in diameter, provided with a handle and having a ridge of metal, semicircular in section, near the periphery of its lower face. A short rod terminating at its lower end in a hemispherical button passes through the centre of the disc, and is connected at its upper end to a spring dial indicator of the type

commonly employed in engineering shops to test the accuracy of setting up work on machine tools. By pressing this instrument on to the doped fabric so that the annular ridge is in complete contact with the surface, the central rod is forced upwards by an amount which depends on the tautness of the fabric, and as the relative movement of the parts is shown on the dial indicator a measure of the tautness is thus obtained.

The dope film formed as above-described, Captain Walpole continued, was permeable to water vapour, and the absorption of moisture caused the fabric to slacken. Waterproof varnishes were therefore used to prevent this, but as the varnish eventually cracks they were only partially effective. Light also had a considerable effect on the film, causing it to slacken in the sun's rays and tighten up again in the shade. This effect was difficult to explain, but it had been found to be quite independent of moisture. In any case the tautness became less and less after exposure, due to molecular disintegration of the dope film, which at last broke up. Excellent results had, however, been obtained by incorporating a pigment with the waterproof varnish, to protect the dope film from the effect of light. A protective coating of this type, known as "Raftite," had been produced by the Royal Aircraft Factory staff, and doped fabrics treated with this coating had been exposed from May to October without any appreciable loss of strength. The strength of other doped fabrics exposed under similar conditions, but without the protective coating, had dropped to one-fourth of its original value, and the films had cracked badly.

Captain Walpole also referred to some work done in connection with waterproof insulating fibre for magnetos, &c., and also to the varnishing of air screws. We regret that the demands on our space prevent us from dealing with these matters. Enough has, however, been said to show that the work of the staff of the Royal Aircraft Factory and the Aeronautical Inspection Department has done much to overcome what may be described as the minor difficulties of aircraft manufacture. A little consideration will also show that this work, although not so important as the design of the machines and engines themselves, must have a considerable effect on the all-round efficiency of our aerial forces. New problems will, of course, arise, many still await solution, and improvements may still be effected in those apparently solved, so that in tendering our thanks to Captain Walpole and his colleagues for their past achievements we may also express the hope that their future efforts will meet with an equal measure of success.

THE BRITISH INDUSTRIES FAIR, 1917.

THE third British Industries Fair, which was opened in London on Monday and will remain open, from 10 to 6 p.m. every day, until March 9, differs in so far from its predecessors as manufacturers are alone allowed to exhibit. Wholesale foreign firms are excluded. It is not a fair in the popular sense. The exhibition is restricted to a few classes of goods, and the general public is not admitted. The Department of Commercial Intelligence of the Board of Trade (32, Cheapside, E.C.), which has been arranging these exhibitions, has a patriotic object in view. The department has issued invitations to 70,000 British buyers, and, further, to 17,000 firms in the Dominions and in neutral countries, for the purpose of bringing manufacturers in direct contact with the respective traders and to enable the manufacturers in particular to demonstrate what progress they have achieved in the making of articles which formerly came from the Continent. To what extent that took place is better known to the trades than to the public. This year's fair is limited to toys and games (in the Imperial Institute), and to fancy goods, printing and stationery, pottery and glass (on the ground floor of the Victoria and Albert Museum). The trade in high-class luxuries is hardly encouraged at present. Though manufacturers are anxious to demonstrate that they can fulfil orders, notices can be seen that the goods displayed are solely for shipping and export, the firms not wishing to make any effort to supply the home demand before the demand from abroad is satisfied, which will bring new money into the country. There are also notices that no orders can be accepted for the present. Toys and games are not important industries; that the country had practically become dependent for some kinds of them on Germany and Austria was more suspected than realised; for questions about origin were not always answered. That glass and porcelain for the chemist were in the same, if not in a worse position, was not appreciated by the public. But it was so, and that fact will help to explain why the British chemical industry has been so hampered in its advance.

There is not much for the engineer at this fair. Many of the firms exhibiting might have made fine shows of their other products; but they were restricted as we mentioned. We will confine our notice to glass and china for the laboratory, and a few specialities. Before doing so we must say a few words about the excellent general arrangements. Most of the stands are commodious and attractive and well grouped for the specialist's interest. The catalogue enumerates the chief products in the alphabetical order of the firms. Classified lists of exhibitors and numerical lists of the stands enable the visitor quickly to find what he is looking for. If the exhibition had been in the proverbial state of unreadiness at the time of its opening, the Queen would not have paid her visit on the opening day. So far the attendances have been good.

When the war broke out glass and porcelain makers in this country were not in a position to supply chemists with flasks, crucibles, tubes, dishes, burettes, &c., of their own make. They had not the knowledge nor the men to do it; their men had to learn everything. All that is now to be seen in this section of the fair represents novelties of the last two years. That is not mere supposition, but exactly what the visitor is told by the manufacturers; and one can only congratulate them upon what they have accomplished. Six of the leading firms formed in 1915 the Association of British Chemical Ware Manufacturers for the purpose of avoiding unsatisfactory competition and overlapping of interests. Certain classes of goods are naturally supplied by several of these firms; in other lines they specialise, and they visit one another's works for this aim. The six firms which belong to this Association and have their exhibits in one block of the fair are Messrs. John Moncrieff, Messrs. Wood Brothers, the Icknield Glass Works, the Edinburgh and Leith Flint Glass Company, Duroglass, Limited, and Messrs. Doulton and Company. Some other firms, who also manufacture laboratory glass and china, have not joined the Association. Optical glass, and also silica ware, in which England excels, are not represented at the fair, nor are technical stoneware goods (pipes, taps, pumps, coils, &c.), which have become indispensable for chemical works; the bulky character of the goods, which also restricted the glass manufacturers, may have excluded them.

What the chemist and engineer want in glass is high resistance, both to heat and chemical corrosion, stability, high weathering power, toughness and hardness. Refractoriness and resistance to strong acids and alkalis are supposed to be characteristic of potash-lime glasses (Bohemian) and also of boro-silicates; flint or crystal glasses (potash-lead) and soda-lime glasses (window glass), and alumina-lime glasses (for bottles) are not suitable for the chemical laboratory. The formulæ of the Glass Research Committee of the Institute of Chemistry, and in particular of Professor Herbert Jackson and Dr. T. R. Merton, of King's College, have been very useful. The toughening and hardening is in general secured by quenching the finished glass in oil or salt solutions, or by shaping the glass in moulds of metal; there are other methods in use, but glass makers do not give information about methods and composition. Hardened glass cannot be worked afterwards, though the slabs can be united, like laminæ, and is apt to disintegrate almost explosively. But it is very strong and hard and will not break when dropped; on the whole, it does not seem to have justified the expectations placed on it, however, and there is not much demand for it. We pass to detailed notices.

The firm of Duroglass, Limited, of 14, Cross-street, Hatton-garden, E.C., and Walthamstow, makes specialities of soft soda-glass tubing for lamp and blowpipe work, and of high-resistance boro-silicates for general apparatus. Their boro-silicate has a melting-point of 1,050 deg. F. and will bear autoclaving for two or three hours at pressures of three atmospheres; combustion tubes are made of this glass. The vacuum-jacket flask, silvered inside the jacket, to be seen on the stand, is for the Heat Commission tests of cordite; there are also dephlegmators, consisting of bulbs and tubes in series, Sydney Young fractionating column apparatus, and mercury-toluol temperature regulators. Carel tubes for irrigating wounds, which comprise short tubes from which three or four vertical tubes extend upward, looking like multiple gas burners, are shown. Particularly noteworthy are the burettes and pipettes and finely graduated flasks and cylinders of the firm; one can hardly imagine how laboratories could exist at all without a ready supply of burettes, the making of which, of course, requires great care.

The Edinburgh and Leith Flint Glass Company, of Norton Park, Edinburgh, specialises in bulbs, tubing (stemming tubes) and rods for electric lamps, and in requisites for artificial eyes, opal "shell" tubes and colourless lens rods. They show, further, various enamel glasses, platinum enamel rods (colourless), iron enamel tubes (blue), copper enamel rods (orange-opal), black vitrite for electric lamp cap patterns, and soft soda tubes.

The Icknield Glass Works (Oslers), Limited, of Freeth-street, Birmingham, supply laboratory and surgical glasses, especially retorts and separating funnels, and Kipp's sulphuretted hydrogen generators; glass shades and bulbs, table glass, &c., are also to be seen.

Messrs. John Moncrieff, Limited, of the North British Glass Works, of Perth, make a speciality of engineering glassware, in addition to high-resistance laboratory ware of all descriptions. Among these are the miners' lamp cylinders and gauge glass guards in flat slabs, which are mounted in metal frames, or in horseshoe form, almost encircling the gauge glass proper. These particular glasses are of toughened glass, which is made in thickness up to 17 mm., thicker plates not being demanded. Needle lubricators, the well-known bottles with wooden stoppers, through which a copper needle slides, are another exhibit which was not made in England two years ago. Connections, traps and faucets for acid plants, Kjeldahl flasks, nitrogen bulbs, drying tubes, hydrometers, and various apparatus of Jena glass formulæ should also be mentioned.

Some of the specialities of Messrs. Wood Brothers, Borough Flint Glass Works, Barnsley, are similar to those of the Duroglass Company. In addition to pipettes and burettes, Nessler glasses, and graduated measuring glasses, we find reagent bottles, weighing bottles, glass stoppers, condensers, T and Y pieces and adapters, thistle funnels, conical beakers, potash and calcium chloride bulbs, Dreschel gas-washing bottles, Liebig condensers; further, also, flash-lamp lenses up to 2½ in. diameter, and X-ray bulbs and tubing.

The dioptric lenses, coloured and colourless, for ship's lights and lanterns, of Messrs. Molineaux, Webb and Co., Limited, Manchester Flint Glass Works, Ancoats, have enjoyed a wide reputation for many years; the firm was founded in 1827. Railway lamp glasses, arc lamp globes and shades, table ware and pressed glassware for silversmiths are other products of the firm, to which more recently retorts for the chemist and tea-cup feeders, lotion dishes, &c., for medical purposes have been added.

The glass wool, free from lead, of the British Glass Wool Company, of 134A, Holloway-road, N., is a war product. The glass wool threads, from 0.0004 in. diameter upward, are recommended for decorations and are well fitted for that; useful applications are brushes—fine for applying corrosives, rough for cleaning dynamo commutators, ink erasing, &c.—and glass wool texture for filtering; coloured skeins are also exhibited.

Though many kinds of British china and art pottery, which are very well represented at the fair, have justly become famous, the chemist appealed in vain to British porcelain makers for his particular china-ware when the war broke out, except perhaps for the speciality of Messrs. Josiah Wedgwood and

Sons, of Stoke-on-Trent, who have, for a long time, been general manufacturers of pestles and mortars and of porous cells for electrochemists, &c. At present two British firms supply porcelain for the laboratory. Messrs. Doulton and Co., Limited, of the Royal Doulton Potteries, Lambeth, S.E., show a great variety of apparatus, basins, beakers, dishes, crucibles of all shapes, combustion boats, funnels, perforated filter discs, filter baskets, spatulas, water-bath rings, trays, tiles, rotors for acid meters about 6 in. in diameter, steam jackets for Beckmann boiling-point apparatus, and porcelain drums for the rotary mercury pump of Gaede.

The Worcester Royal Porcelain Company, of Worcester, are the other firm. They have the same articles, including also basins tinted green inside to make colourless deposits more perceptible, glazed and unglazed—the green glaze is said to wear as well as the ordinary glaze—Gooch crucibles with perforated bottoms (also made by Messrs. Doulton), Rose crucibles, Buchner funnels (with perforated filter discs), dye pots with flanges, small basins (casseroles) with lip and flat handle, and, as specialities, combustion and pyrometer tubes, glazed on both or on one side only; pyrometer tubes are made in lengths of 1,700 mm. A report from the National Physical Laboratory, dated January, 1916, proves that the porcelain dishes passed the reagent-tests (boiling sulphuric acid, caustic soda and carbonate of soda at 100 deg. C.) as well as Berlin porcelain; the behaviour of the glaze at high temperature, the constancy of weight, and resistance to sudden changes of temperature were likewise equally satisfactory.

Stoneware is hardly represented, so far as the engineer is concerned, though abundant otherwise. We may mention the well-known Berkefeld filters of the British Berkefeld Filter Company, Abbey Hey Works, Manchester. Tubes or cylinders of kieselguhr, closed at one end, are mounted in stoneware cylinders, and the water passes through the cylinders, which retain bacteria and also lead; muddy water is best filtered previously. Up to six of these tubes are fixed in one cylinder; the filter may be combined with hand-pumps. To clean the kieselguhr tube it is boiled in a tray for about an hour. The Brownlow filters of Messrs. Clarke and Brownlow, of Gorton, Manchester, contain compressed carbon blocks.

Finally, we notice the anglite, a substitute for the German galalith, of Anglite, Limited, 68, Cowcross-street, E.C. The material is supplied in sheets of various thicknesses and colours, and is used like amber, horn and vulcanite, being an non-inflammable insulator; the essential constituent is casein, as we recently pointed out.*

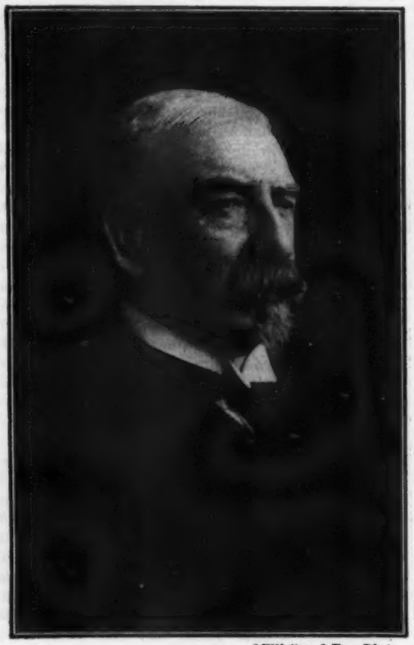
A somewhat similar fair is now open at Glasgow.

THE LATE MR. WILLIAM HENRY HUNTER.

WE regret to have to announce the death, which occurred last Tuesday, February 27, at Bank House, Woodley, Cheshire, of Mr. William Henry Hunter, a member of the Institution of Civil Engineers, a member of the American Society of Civil Engineers, formerly chief engineer, and, since 1910, consulting engineer, to the Manchester Ship Canal Company.

Mr. Hunter, whose portrait we give on the present page, was born on June 16, 1849, and was the son of the late Mr. Henry Hunter, of Sunderland. He was educated at private schools and at the College of Physical Science, Newcastle-on-Tyne. He served a pupilage of five years, from 1865 to 1870, with Mr. Thomas Meik, being engaged in the engine shops, drawing office, and in the works carried out by the River Wear Commissioners, Sunderland. From January, 1870, to January, 1872, he was an improver and assistant in the office of Messrs. Meik and Nisbet, Edinburgh and Sunderland, when he was engaged on harbour and dock work on the rivers Wear, Blyth and Coquet, at Burntisland and Ayr, also on surveys for the Hylton, Southwick and Monkwearmouth Railway. From January, 1872, to September, 1873, he acted in the capacity of resident engineer on the construction of this railway; then, from September, 1873, to June, 1882, he was assistant engineer on the River Weaver Navigation, at first under Mr. J. Watt Sandeman and afterwards under Mr. L. B. Wells. During this period the River Weaver Navigation was entirely remodelled and adapted for ocean-going vessels.

Mr. Hunter's connection with the Manchester Ship Canal dates from the year 1882. From June in that year until September, 1887, he was chief assistant to Mr. E. Leader Williams, having charge of the preliminary and detailed surveys, drawings and estimates for the ship canal, and assisting in the proceedings involved in the contest for obtaining Parliamentary powers for carrying on the works. On the date last named he became principal assistant engineer under Mr. Leader Williams, the engineer-in-chief, and Mr. Abernethy, the consulting engineer, on the Manchester Ship Canal works, and in that capacity he was directly and responsibly concerned in the design and execution of the whole of the works from Eastham to Manchester, including the canal proper, with its contingent works, the docks and the deviation railways. In the year 1895 he



[*Elliott and Fry, Photo.*

THE LATE MR. W. H. HUNTER.

was appointed chief engineer, a position which he held for 15 years, becoming consulting engineer to the company in 1910.

In June, 1899, Mr. Hunter read a paper before the Institution of Civil Engineers' Conference, on "The Discharging and Reloading of Large Steamers," in which he pointed out the financial advantage of rapid work in docks and reviewed the facilities provided at the Manchester Ship Canal for dealing with all kinds of cargoes. On that occasion he stated that the great aim was to get as much floor space as possible within a reasonable distance of the hull of the ships, so that the cargo could be swung to adequate floorage area at one movement. Some criticism having been offered as to his four-storey arrangement for the Manchester Ship Canal sheds, he added that he had tried all heights up to that, and when designing the sheds—which were illustrated at the meeting referred to—he had seriously considered the advisability of making a fifth storey. The paper in question gave evidence of the extreme care with which he had approached the problem set forth in its title, a problem to which he gave a satisfactory solution in all its bearings.

Mr. Hunter frequently took part, at the meetings of the Institution of Civil Engineers, in the discussion of papers dealing with canal and water works. On one occasion he stated that, after trying different methods of lighting, he had adopted acetylene lamps at the Manchester Docks, inasmuch as these gave a light that was locally bright; they were, moreover, portable, and absolutely safe as far as the danger of fire in the holds of steamers was concerned. He also dealt with the work of the Mersey and Irwell Committee on the purification of water from manufactories, on the treating of waters by filtration, and on the sanding-up of tidal harbours, all subjects on which he had acquired considerable experience.

Mr. Hunter was also at one time a member of the Technical Committee, a committee which had under consideration the plans for the French Panama Canal scheme; in the year 1905 he was selected to represent Great Britain on the Board of Consulting Engineers appointed by the President of the United States to consider the plans for the American Panama Canal project. In a communication to the United States Senate Committee, in June, 1906, he strongly justified the majority vote in favour of the sea-level plan for the Panama Canal, largely from the standpoint of his experience of the objections arising from the existence of locks. After instancing accidents due to locks and stating that those proposed in the minority report would have a width of 95 ft., a differential head of water behind the gates of 28 to 30 ft., and a depth of water behind the gates of 68 to 70 ft., he stated that if the gates were carried away by a downward-bound vessel, nothing could stop the rush of water; the velocity of the stream through the lock would be such that any vessel would be carried on thereby. He also criticised various features of the Panama Canal as then proposed, and refuted the objections made against the sea-level plan, which, he thought, could be completed in 10 years. We state these latter points simply with a view to emphasise the reputation which the subject of the present memoir had acquired in all work which pertained to canal and harbour construction, equipment and operation.

MINING IN THE UNITED KINGDOM.

IN the course of his recent report to the Home Office, Sir R. A. S. Redmayne, H.M. Chief Inspector of Mines, states that for the year ended 1915, the year covered by the report, the total output of coal in Great Britain was 253,206,081 tons, valued at 157,830,670*l.*, showing a decrease in output of 12,458,312 tons, and an increase in value of 25,233,817*l.* on the figures for 1914. The average price of coal was 12*s.* 5.60*d.* per ton in 1915 and 9*s.* 11.79*d.* in 1914. The quantity of coal exported, exclusive of coke and manufactured fuel and of coal shipped for the use of steamers engaged in foreign trade, was 43,534,560 tons, of which France received over 17,500,000 tons, Italy over 5,750,000 tons, Denmark over 3,000,000 tons, Sweden and Norway each over 2,500,000 tons, the Netherlands over 1,750,000 tons, Spain and Argentina over 1,500,000 tons each, and Egypt over 1,250,000 tons. Adding 2,786,401 tons exported in the form of coke and manufactured fuel, and 13,630,964 tons shipped for the use of British and foreign steamers engaged in foreign trade, the total quantity which left the country was 59,951,925 tons in 1915, as against 80,993,890 tons in 1914.

The amount of coal remaining for home consumption was therefore 193,254,156 tons. Of this quantity 37,284,600 tons were used in the manufacture of coke and briquettes, and 2,509,456 tons of coal, with 9,746,743 tons of coke (equal to 16,244,572 tons of coal), in blast-furnaces for the manufacture of pig-iron, as against 36,289,010 tons and 18,381,106 tons respectively in 1914.

The largest output of coal was in Yorkshire, where the yield was 40,343,694 tons, followed by Durham, with 33,737,865 tons, Glamorgan, with 33,110,247 tons, Lancashire, with 21,405,081 tons, Derby, with 16,645,131 tons, and Lanark, with 15,393,799 tons.

In the above total quantities for coal the output of anthracite enters for 4,712,145 tons, valued at 3,568,658*l.* Further, the output of coal in Kent in 1915 enters also in the total quantities for 158,389 tons (being 27,949 over the figure for 1914), valued at 113,090*l.*

The following information on the number and kind of coke ovens in use in the United Kingdom during the year 1915, the figures for 1914 being given in brackets, will be specially interesting to metallurgists and to firms dealing with the by-products of coal distillation:—Beehive, 7,521 (9,210); Coppée,

* See ENGINEERING, page 164 *ante*.

1,343 (1,538); Simon-Carves, 1,766 (1,354); Otto Hilgenstock, 2,034 (1,589); Semet-Solvay, 1,251 (1,134); Koppers, 1,241 (916); Simplex, 486 (428); Huessener, 404 (384); Bauer, 40 (43); Collins, 171 (95); Mackay Seymour, 32 (32); other types, 285 (302).

In regard to iron ore, 7,876,105 tons, valued at 3,855,075*l.*, were obtained from mines, and 6,358,907 tons, valued at 732,578*l.*, from quarries in the United Kingdom in 1915, or a total of 14,235,012 tons, which yielded 4,567,351 tons of pig-iron, or more than half of the total quantity of pig-iron made in this country, the total production of pig-iron in the United Kingdom from iron ores of both British and foreign origin having been, in 1915, 8,723,560 tons (as against 8,923,773 tons in 1914). Of the total of 8,723,560 tons obtained, 612,848 tons were exported, leaving 8,110,712 tons available for home consumption.

Among the other metals obtained from British ores the report gives the following figures of output for the year 1915:—Antimony, 4 tons, of an estimated value of 380*l.*; copper, 234.5 tons, valued at 19,600*l.*; gold, 1,256 oz., valued at 4,027*l.*; lead, 15,520 tons, valued at 355,149*l.*; silver, 96,448 oz., valued at 9,519*l.*; tin, 4,968 tons, valued at 815,746*l.*; and zinc, 4,096 tons, valued at 273,135*l.*

An interesting item referred to in the report is oil shale, of which 5,976 tons were mined in Stafford and 2,992,676 tons in Scotland. The average yield of oil for Scotland is 20 gallons, and of sulphate of ammonia 44 lb. per ton of shale. This average yield of oil would appear to us to be low in view of the figures put forward by several British firms owning distilling processes, who claim to produce between 50 and 90 gallons of fine oil per ton of shale. A yield of 90 gallons of oil would appear to us to correspond to about four-tenths of the measurement of the shale, a very high yield, which speaks both in favour of the shale and in that of the distillation processes.

It is also interesting to note that over 310 tons of tungsten ores, valued at 38,672*l.*, were obtained from mines and open workings in Cornwall; over 13 tons, valued at 2,034*l.*, from mines in Cumberland; and 8 tons, 8 cwt., valued at 4,097*l.*, from mines in Devon, during the year 1915. The ores from Cornish mines contained an average of 64 per cent. of metal.

The mines and quarries at work in 1915 under the Coal Mines Act, the Metalliferous Mines Act and the Quarries Act numbered 10,132, and they gave employment, underground in mines and inside at quarries, to 56,916 males under 16 and 749,653 males over 16. The employees above-ground at mines and outside at quarries numbered 221,270 males and 7,759 females. The total number of underground male employees, therefore, numbered 806,569 in 1915, as against 979,880 in 1914, or 173,311 less in 1915; whilst as against the 221,270 males working above-ground in 1915, there were 249,683 in 1914, or 28,413 less in 1915. Taking the two figures together, there were 201,724 males less in all mining and quarry work in 1915 than in 1914.

We find that in 1915 there were 638 collieries in which coal-cutting machines were at work, as against 652 in 1914. The total number of machines employed was 3,089, or 4 less than in the preceding year; of these, 1,449 were worked by electricity and 1,640 by compressed air. The total quantity of mineral obtained in 1915 by the aid of these machines was 24,510,124 tons, this being an increase of 235,607 tons on the figure for 1914. The Scotland Division, No. 1, and the York and North Midland Division, No. 3, took the lead as regards the number of machines employed, nearly 54 per cent. of the total number of machines in use being found in these two divisions.

NOTES.

FRENCH NAVAL CAPTAINS.

WE read in the *Moniteur de la Flotte* an official report made to the French Parliament in regard to a Bill which was introduced on January 11 with the object, among others, of re-establishing the rank of *capitaine de corvette*, a naval officer ranking with major. The rank of corvette captain was instituted by a decree dated March 1, 1831; it replaced that of frigate captain, which, as a matter of fact, only ran out in December, 1836. The decree of 1831 gave to the *capitaines de vaisseau* the command of ships of the line and of first-class frigates; the frigate captains could command second-class frigates, and commanded at all times all the third-class frigates, also the corvettes armed with 24 and more guns and the service corvettes. The corvette captains were given the command of all warships carrying from 10 to 22 guns, together with that of the bomb-ketches, large steamers and all armed transports. A decree of May 3, 1848, abolished the rank of corvette captain and re-instituted that of frigate captain, the corvette captains then on the active list being placed in the list of frigate captains. For many years past the re-institution of the rank of corvette captain had been demanded by Ministers, Parliamentary Commissioners, and technical men. The report of January 11, to which we refer above, states that the re-institution of the rank in question is a necessity. The main objection raised against the measure had been based upon the difficulty of finding a sufficient number of occupations for officers of that rank. On the other hand, the increase in displacement of both large and small units, coupled with the very great complexity of the machinery of present-day warships, requires the presence on board of a staff of officers greater in number than formerly, more specialised, and "hierarchised" differently. The grouping of duties is found necessary in the units of the Danton and Bretagne class. According to clause 248 of the decree of May 15, 1910, the main groupings now comprise the officer in command, the second in command, followed by those of navigation, artillery, landing, torpedoes and electricity, engines, safety measures, stores and sanitation. Corvette captains being available, the distribution of duties could be as follows:—(*a*) On the battleships of the Danton class and of later types a corvette captain would command the offensive, and have charge of artillery, torpedoes and electricity, and landing detachments. A second corvette captain would command the defensive, having under his charge the safety measures, and be attached to the second in command for current duties. (These functions are now devolved to frigate captains.) (*b*) On the battleships older than the Danton, and on the armoured cruisers, the corvette captains would have command of the offensive. (*c*) The corvette captain would be second in command on a ship commanded by a frigate captain. (*d*) He would command the large torpedo boats and special ships, such as minelayers. (*e*) There would be two corvette captains on the staff of each squadron commander. The re-institution of the rank of corvette captain would also be of advantage in that capable officers would not remain, as is now pretty frequently the case, eighteen years with the rank of lieutenant.

STRUCTURE AND STRENGTH OF METALS.

Professor W. E. Dalby, F.R.S., introduced his lecture on "The Strength and Structure of Metals," delivered at the Royal Institution last Tuesday, by a very instructive reference to the phenomena of the depression of the freezing-point. Guthrie, he said, observed 40 years ago that, when he added more and more common salt (NaCl) to water, the freezing-point of the solution was more and more depressed until the solution contained 23½ per cent. of salt by weight; it then froze at − 22 deg. C. When more salt was added the freezing (or melting) point rose again. The salt-water mixture which froze at − 22 deg. he called the eutectic, to indicate that it was the most fusible mixture of the lowest freezing-point, corresponding to what the mother-liquor would become if the solution were completely frozen. Expressed in molecular ratio, 9 parts of salt seemed to prevent 91 parts of water from freezing before − 22 deg. was reached. Broadly, one might say 1 molecule of salt had this effect on 10 molecules of water. Thus 4 molecules of salt would keep 40 of water liquid, and 20 molecules of salt should have the same effect on 200 molecules of water. The freezing eutectic formed a lump of ice in which blocks could be distinguished which were laminated in different directions. When there were 4 molecules of salt present (less than 9), crystals of ice could be seen in the eutectic; when 20 molecules of salt were present, crystals of salt would become visible; both this ice and the salt would crystallise before the eutectic. The solidification of metals and alloys took place on analogous lines. Gold melted at 1,064 deg. C., thallium at 290 deg. When the two metals were fused together, complete solidification occurred at 131 deg., when a eutectic of 27 per cent. of thallium separated out. When temperatures were plotted as ordinates against compositions, and a line drawn from 290 to the point 27–131, and another line from this point to 1,064, the space between these two lines would represent the all-liquid phase, whilst there would be solid thallium and liquid on the left of the first line, and gold and liquid on the right of the second line. Similarly it was with iron-carbon alloys. Pure iron itself melted at about 1,500 deg. C. When carbon was thrown into the fused iron, compounds were formed and solidification would, *e.g.*, set in at 1,150 deg. But what was found in the cold iron did not necessarily represent the structure of the metal as first solidifying. When the cooling curve of a metal was regular, no change in structure would occur. The cooling curve of carbon-iron showed a recalescence at 730 deg., however, below which iron became magnetic, and such iron had undergone changes in structure; one might think of the historical changes of styles of architecture. The carbide formed was known as cementite; dissolved in iron (ferrite grains) it crystallised as austenite; this changed into pearlite at 730 deg., a eutectic of an average carbon percentage of 0.9, containing about 7 parts of cementite and 1 of iron, in alternating laminæ. Of these laminæ, Professor Dalby had counted up to 60,000 per inch. The crystal blocks were, in metals, mostly of irregular outlines, because crystallisation started from many points and proceeded in some direction until stopped by a crystal growth in a different direction. In microscopic specimens the blocks might lie flat or at any angle, and blocks of the same kind might for that reason look very different when illuminated. To illustrate the structure of a small portion of the polished and etched surface very intense illumination was needed. With the aid of a projecting microscope Professor Dalby threw exceedingly interesting images of samples on the screen. The specimen was first shown at a small magnification, which was then increased finally to 2,000 diameters, to reveal characteristic detail. The structure, and even the colours, came out beautifully. In brass, cubes, all oriented the same way, could distinctly be seen. Steels and pig-iron very clearly showed the dendritic structure, the scales of graphite, the pearlite, first seen in dark patches, the white crystals of cementite, the grey crystals of carbide and phosphorus, both resembling ice crystals, and the spots in which the manganese sulphide concentrated on the boundary of a crystal block. In the second part of his lecture Professor Dalby dealt with tensile tests of brass, phosphor bronze, steel, &c., remarking that the peculiar features of the strength curves, the apparent rise in the strength following the period of yielding and the sudden breakdown, were not yet understood.

INSTITUTION OF CIVIL ENGINEERS' LECTURES.—The Council of the Institution of Civil Engineers hope to arrange for the delivery at extra meetings of lectures on the decimal system of coinage, weights and measures, on the standardisation of engineering materials, &c. It is thought that the consideration of these special subjects is of special importance to engineers generally at the present time. Discussions of the issues raised by the lectures will be invited, and the meetings will be opened to the press. The first lecture, on "Foreign Trade and its Relation to the Investment of Capital Abroad," by Mr. Edgar Crammond, will be delivered on Monday, the 12th inst., at 5.30 p.m.

CANADIAN INDUSTRY.—The total census of manufactures in Canada taken during 1914, says *Canadian Machinery*, shows that the number of establishments had increased during the last decade from 15,796 to 21,291. The total capital, including value of land, buildings, machinery, materials and stocks on hand, and operating capital owned or borrowed, had advanced from $846,585,023 to $1,984,991,427, or 134.47 per cent. The wages bill had increased from $134,375,925 to $227,508,800, or 69.31 per cent., and the salaries bill from $30,724,086 to $60,143,704, or 95.75 per cent. The value of products in 1915 was $1,393,516,953, an increase of $674,164,350 over 1905. The total value of goods manufactured for war purposes actually completed and delivered during 1915 amounted to $130,466,307, a total which, it is expected, will be increased by several millions in the final return.

LITERATURE.

Strength of Ships. ATHOLE J. MURRAY, Grad. R.N.C. (Greenwich), Assoc.M.I.N.A. Longmans, Green and Co., 39, Paternoster-row, London. [Price 15s. net.]

THAT the developments in the art of shipbuilding have not been comparable in point of economic importance with the advances made in the design and construction of propelling machinery during recent years is well known to all students of the history of naval architecture, and the reasons for the comparative stagnation in the evolution of ship construction are not far to seek. In a general way it may be said that as regards form of hull no very essential departure from the modified box form is possible, having regard to the requirements as to carrying capacity, stability and strength, such modifications as are possible being confined largely to improvements in materials, disposition of these materials, and methods of construction.

The transitions from wood to iron and from iron to steel are fairly well defined steps in the evolution of the hull so far as materials of construction are concerned, and each has had a marked effect in modifying the structural design so as to utilise to advantage the extra strength of the newer material. With the definite adoption of steel as the material of construction many changes became possible owing to the extra strength and ductility of mild steel, and these changes were gradually introduced into the shipbuilding practice of the time. There is no doubt that realisation of the full advantages of the use of steel in place of iron was much retarded by the difficulty of designing the parts of the ship's structure on a satisfactory theoretical basis, and by the conservatism of shipowners and of the registration societies. The chief difficulty which the ship designer has to face lies in the indeterminate character of most of the stresses to which the various parts of the ship's structure are subjected, owing to the fact that it is practically impossible to localise these stresses with any degree of certainty, and also to the fact that the value of the performances of structures composed of plates and angles riveted together, and themselves forming part of a still more complicated structure, cannot be quantitively expressed with any degree of certainty.

A good illustration of the difficulties met with is the case of a deck girder used to lift and transport parts of machinery in the engine-room. Such a girder would be composed of plates and angles riveted together, the whole being riveted to the under side of the deck plating and attached by means of angle lugs or plate brackets to the beams. Some of the beams, and possibly the girder itself, would be supported by pillars at moderately wide intervals. It will readily be seen that any local stress on the girder, due to the lifting or traversing of a weight, is communicated to the deck plating, beams and pillars, and is distributed over them in varying proportions which it is mathematically impossible to evaluate. The determination of the parts of the structure which should be taken into account in the strength calculation and the value to be assigned to each becomes, therefore, very largely a matter of judgment and experience rather than calculation. It is the practice in some of our most important shipyards to make careful calculation of the deflection anticipated in girders or other such structures under test, and to compare these results with the actual results got by a carefully conducted practical test under working conditions. In this way the total value of the unknown factors is accurately found, and future calculations for similar structures can be modified in accordance with the test results and thereby made directly applicable within a reasonable limit of error.

In view of these difficulties in the way of direct application of mathematical investigation to many parts of the ship's structure, and having regard to the disastrous nature of the consequences which may follow upon a too drastic reduction in scantlings as a result of working strictly in accordance with the results of scientific investigation, it is not surprising that development has been somewhat slow and has been based to a very large extent upon scientific investigation of successes and failures in actual service rather than upon original calculation. The accumulation of an enormous mass of data bearing upon the behaviour of vessels under actual service conditions has thrown much light on the correct value of calculated results, and has shown in what degree and to what extent assumptions made or results achieved may have to be modified in order to establish a reasonable agreement between observed and calculated results.

In "Strength of Ships," Mr. Murray deals with the mathematical treatment of strength problems as they apply to the completed ship considered as a girder subjected to hogging and sagging, racking and pitching stresses, and also investigates mathematically the strength of various items of structure and equipment, such as derricks, davits, bulkheads and bulkhead stiffeners, pillars, brackets, &c., in a most exhaustive manner. Much of the subject-matter of the book is dealt with in the numerous text-books on applied mechanics, but many of the calculations and methods of investigation are original and of great interest and value in providing a reasonable basis for the scientific determination of the scantling of parts which are at present based very largely upon previous practice without much reference to possible excess or defect of strength.

Starting with a few notes on moment of inertia, with which are incorporated tables of formulæ for the areas and moments of inertia of circles and various rectilinear figures, the author passes to definitions of stress, strain and elasticity. Under the heading of "Materials of Ship Construction" are given the compositions and uses of a number of the metals used in shipbuilding, together with their physical properties. The testing of specimens and the definition of factors of safety are included in the chapter.

The strength and stiffness of beams is one of the most essential elements in strength calculations as applied to ship work, for the method of treatment applied in the majority of structural strength calculations is to endeavour to treat the item under consideration as a beam loaded and supported according to the particular circumstances of the case. It is therefore appropriate that the chapter devoted to beams should be thoroughly comprehensive and should deal with a large variety of conditions of loading and support. Attention is called to the discrepancies which exist between the calculated and observed deflections of compound beams, and in some cases figures showing the amount of this discrepancy are given, and although the more complicated cases are not investigated, sufficient is given to indicate the necessity for the collection and tabulation of experimental data on all possible occasions.

Pillars are an essential feature of the structural design of all vessels, and are also used in a variety of forms for resisting and distributing local stresses. Mr. Murray, who has already made contribution to the study of pillars, has dealt at length with the subject, indicating the various formulæ commonly used for such calculations and showing methods of dealing with eccentrically loaded pillars, and also with head and heel connections. For the determination of the size of such local pillars as it may be found necessary to introduce, and for which the rules of the registration societies provide no table of sizes, the rules and tables given in this chapter will be found of great value.

A short chapter on the resistance of shafts to torsional and combined torsional and bending stresses will be found useful in dealing with problems connected with the strength of rudder stocks of balanced rudders, steering gear shafting, &c.

The calculation of the hogging and sagging stresses to which a vessel may be subjected while on service, and under extreme conditions of loading, is very necessary where the structural features of the vessel or the conditions of service or loading depart in any marked degree from the generally accepted standard for that class of vessel, and is now very commonly undertaken during the design stage. A very full description of the method of performing this calculation, both in the upright and inclined conditions, and including a description of the trochoidal wave theory and the "Smith" correction due to variation of pressure in the wave, is given, also diagrams illustrating the graphic calculation for bending moment for the hogging and sagging conditions for typical ships. The calculation of the transverse strength is much less commonly carried out in practice, but to those who have occasion to apply this most interesting investigation the description and examples given by Mr. Murray will prove of immense value.

During recent years a great deal of attention has been devoted to the question of the strength of bulkheads, and that this study of the problem was very necessary has been amply proved by the findings of the recent Bulkhead Committee. As is the case with so many other ship-strength calculations, really reliable results for bulkheads are only to be got from experiments during the testing of actual bulkheads under water pressure, and then only under still-water conditions. To the theoretical consideration of the problems involved Mr. Murray has previously contributed, and his chapter puts the student in possession of all the information necessary for the calculation of the strength of bulkhead stiffeners in association with a variety of attachments of heads and heels, and also such information as is available for the theoretical determination of the thickness of plating required.

Chapters are devoted to rivets, bolt and tap fastenings; rigging and outboard fittings such as eyeplates, hooks, &c.; plate brackets acting directly as supports to local weights; and strength of rudder forgings.

A somewhat annoying defect is to be found in the lettering of many of the small diagrams—in many cases it is extremely difficult to read the dimensional letters—and the uniform adoption of block letters wherever possible would be of great service. The book will prove of interest and value to the earnest student of naval architecture, and will be of considerable help to those whose business it is to design steel structures for which no data from previously built similar structures are available, but, on the whole, the major part of it will be of academic rather than practical interest to the majority of designers—to whom Lloyd's Rules and previous practice constitute the final authority on scantlings.

The Testing of Machine Tools. By GEORGE W. BURLEY, Wh. Ex., A.M.I. Mech. E. London: Scott, Greenwood and Son. [Price 4s. net.]

THIS work is one of the Broadway Series of Engineering Handbooks and is designed to deal with the various aspects of machine-tool testing in such a way as to make the book suitable for engineer apprentices and students as well as responsible engineers. The first half of the book deals with the testing of machine-tool elements and machine tools for accuracy, describes the instruments used for testing, and explains the mode of procedure. In the remainder of the volume the author treats of tests of machine-tool speeds and feeds, machine-tool efficiency, cutting force tests and tests of output and consumption of power. The book is written with the object of affording assistance to engineering teachers and others who have charge of classes in machine-tool testing.

The author, who is a lecturer on the theory and practice of machine tools in the University of Sheffield, has evidently a thorough knowledge of his subject, but the arrangements and classifications adopted point either to haste in production or to absence of a definite scheme of general and detailed treatment of the branches of the subject. Thus in the introductory chapter the author classifies the tests of machine tools in 10 classes, which he divides into three general sections. Class 2 deals with checking machine tools and machine-tool elements for accuracy, and is treated of in Chapter II. Class 9 deals with tests for checking design, such as tests of speed arrangements; Chapter III treats of speed and feed tests. Class 2 comprises mechanical efficiency tests, and is treated of in Chapter IV. Class 3, cutting-force tests, is treated of in Chapter V. Classes 4 and 5 come into Chapter VI; Classes 6 and 8, cutting efficiency tests, are mentioned in Chapters VII and VIII; while classes 7 and 10, wear tests and tests of metals for machining properties, do not receive individual attention, except that in Chapter II a method is described for testing a machine bed for wear. Similar deviations from classification occur in other parts of the treatise.

At the present time the need for tool-setters and for initial accuracy in machine tools is so great that it is to be regretted that the author should have followed the laboratory methods of testing so closely,

with consequent neglect, in the brief space at his disposal, to explain how these results can be obtained in the workshop without special devices. That portion of the work which deals with the tests of machine-tool elements is innocent of any hint as to how tightly the bearings should be fitted or adjusted, what influence the presence of the lubricant, necessary when the machine is in actual work, will have on the tests, nor does it deal with the very important question of the spring of the tool-post and slides under load. Measurements described by the author are made by means of various micrometers and indicators, some of elaborate construction, but results quite as good have to be obtained in many instances in practice by the use of a set of feelers supplemented by cigarette paper for 0.001 in., neither of which are mentioned in this part of the work. The author also omits to deal with that starting-point in all machine and instrument setting, scarcely, if ever, mentioned in books, the necessity for taking up all backlash by a movement in the required direction before any readings of measurement are made. The fact that continuous movement in one direction for screws, slides and dividing heads must be made to eliminate errors due to backlash is of such importance that it could well find a place in all elementary books dealing with the measurement and correction of errors. The whole of the questions affected by backlash, the difficulties which it creates in screw-cutting in the lathe, or in setting successive cuts on milling machines, are scarcely mentioned, and although backlash of the cross-slide screw and of the top-slide screw are mentioned in the typical form of an inspector's report on a lathe, quoted at the end of the book, nothing is mentioned in this as to the fit, engagement and backlash of the nut engaging with the lead-screw. The chapter on machine-tool speed and feed tests is much more carefully written, and the author makes a good and clear comparison of the relative merits of arithmetical, geometrical and harmonical progressions, and although one formula (23) should read

$$R = \frac{1}{r\left(\frac{n}{2}-1\right)}$$

this portion of the work will be found useful by those who have to design speed-change gear and to arrange the sizes of countershaft pulleys and the further changes of speed which these involve.

In the chapter on machine-tool efficiency the author describes various methods for comparing the input and output of machine tools. These comparisons are interesting, and the methods suggested are generally sound, but the tests are such as generally can be made only in the test-room of a machine-tool manufacturers' works, or in a specially equipped laboratory.

Numerous printer's errors, possibly due to war conditions, mar the typography of the book, though some are probably not the fault of the printer, for example, *affected* for *effected*, which occurs twice, as well as several grammatical errors. The index is very imperfect, and some of the references are under unlikely headings; for example, *straight-edge* is given under *Edges, straight*.

We think that the author would have been better advised if he had separated those tests which are made on existing machines as delivered to factories from the more accurate manufacturers' tests and the still more exhaustive laboratory tests which are his speciality. If in a subsequent edition he rearranges his matter, and deals with the workshop requirements in the first place, and with the methods necessary for securing the commercial accuracy as of next importance, the utility of the book to students and to those in charge of manufacturing works will be assured.

Hydraulics. By R. L. DAUGHERTY, A.B., M.E., Assistant Professor of Hydraulics, Sibley College, Cornell University. New York: McGraw-Hill Book Company, Inc. [Price 10s. 6d.]

THIS book is the work of one who has had considerable experience in teaching, and seeks to remove from the paths of others the difficulties that have beset his own. He urges, and it must be a common experience of teachers, that few students have a true physical conception of the subject of hydraulics. To most of them, till engaged in practical work, it remains an abstract subject, presenting a series of ingenious problems, or, as the author calls them, mathematical gymnastics, to be solved by the application of rules having, apparently, scant connection with actual machinery and practical affairs. Pupils form no adequate mental picture of the physical facts, and are more heavily handicapped than engineering students who have command of well-filled workshops with full-sized models. The size of the machinery employed is a stumbling-block to many, and Professor Daugherty endeavours to minimise this difficulty by conveying some notion of the appearance, construction and arrangement of such machines as turbines and centrifugal pumps, as a preliminary to teaching their mathematical theory. The effort is well-intentioned, but we doubt its efficacy. This description will serve to show that the book is of an elementary character, covering general fundamental principles rather than attempting the detailed or special treatment of hydraulic machinery. This is the most that can be done in the class-room, and considering that this branch of mechanics is not an exact science, that judgment and experience have to supplement rigorous deduction, the author's general plan and method of presentation can be recommended.

Starting with the definition of pressure, or of intensity of pressure, illustrated by means of the Fortin barometer and some forms of instruments for measuring pressure leading to the description of a simple form of hydraulic press, the main principles of hydrostatic pressure are discussed. The author, keeping in view the necessity of presenting fundamental principles, confronts the pupil with the general lines of dam structure, avoiding perplexing details, but affording further illustrations of pressure, and especially calculated to interest the pupil, as he is brought at an early stage into contact with the initial mechanism in the construction of irrigation and power works, destined to play so large a part in the future progress of our empire.

Probably every teacher has some misgivings when he approaches the subject of hydrokinetics, and has to admit the unsatisfactory relations between the mathematical theory and practical conditions. The author frankly admits that the most we can expect from theory is to provide a framework upon which to hang the results of experimental investigation. It is easy to show that water does not flow in parallel threads, that mathematical equations deal only with a component of the true velocity; it is not so pleasant to admit that successful hydraulic engineering depends at last on judgment and experience, factors that cannot be taught by the ablest professors. But the teacher can and should warn his pupils of pitfalls, of the inaccuracy of constants, of the dangers attending too strict an adherence to unreal conditions, introduced to simplify mathematical analysis, and at the earliest opportunity, when the Bernouilli theorem is under examination, the student is taught here the nature of the special case that the theorem covers and the need for careful application. The warning is valuable, but, practically, the introduction of additional terms and factors required by theory is of little use, since the effects of friction and eddies are very imperfectly known, and the margin of error, or of safety, includes more unknowns than the uncertainty arising from general assumptions, such as that the effective head remains constant along any stream-line.

Skilfully and naturally the pupil is conducted through the ordinary applications of hydrokinetics, and learns the use of the Venturi meter, the objects and construction of weirs, and the methods and difficulties in the measurement of water. The treatment of the flow of water through pipes and open channels follows the usual lines. The familiar formulæ of Chezy on the one hand, and Kutter on the other, are duly dilated upon, though we doubt if the consideration of the constant in the equation

$$V = c\sqrt{ms}$$

is warranted by its educational value. The discussion is to be found in all manuals, and thought to be indispensable, but it suffers from the fact that all authors think it necessary to discount its value by substituting a simpler and more convenient practical process. Professor Daugherty strikes at the fundamental principle on which Kutter's formula is grounded when he writes "Any formula that attempts to cover too large a field must necessarily be a mere average of a number of scattered values, and, though giving approximate values at least for any combination of factors, it cannot be expected to give exact values in individual cases. Hence too great reliance must not be placed upon values given by the use of this or any other such empirical formula."

An admirable chapter on hydrodynamics follows, in which will be found a correct theory of the Pitot tube, and some introductory theories on angular momentum, with the application to the action of turbines and pumps necessary to the more complete discussion of the theory of the Pelton wheel, reaction turbines, &c. The description of these instruments, accompanied by many photographic illustrations, is very interesting, but the chapter on water-power plants is inadequate, and will probably be much extended in some future work, for the author apparently regards this book as an introduction to monographs that he has written on special applications of hydraulic power. Viewed in this light the book is very satisfactory and should be welcomed by teachers and students alike, as providing an admirable groundwork on sound and appropriate lines.

BOOKS RECEIVED.

Department of the Interior, Bureau of Mines, U.S.A. Bulletin 105. *Black Damp in Mines.* By G. A. BURRELL, I. W. ROBERTSON and G. G. OBERFELL. *Bulletin* 106. *The Technology of Marble Quarrying.* By OLIVER BOWLES. *Bulletin* 116. *Methods of Sampling Delivered Coal, and Specifications for the Purchase of Coal for the Government.* By GEORGE S. POPE. *Bulletin* 121. *The History and Development of Gold Dredging in Montana.* By HENNEN JENNINGS. *With a Chapter on Placer-Mining Methods and Operating Costs.* By CHARLES JANIN. Washington: Government Printing Office.

Joseph Pennell's Pictures of War Work in England. Reproductions of a series of drawings and lithographs of the Munition Works made by him with the permission and authority of the British Government, with Notes by the Artist and with an introduction by H. G. Wells. London: William Heinemann; Philadelphia: J. B. Lippincott Company. [Price 6s. net.]

Stresses in Structures. By A. H. HELLER. Revised by CLYDE T. MORRIS. Third Edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 11s. 6d. net.]

The "Practical Engineer" Mechanical Pocket Book and Diary, 1917. (With Buyers' Guide in French, Spanish and Russian.) London: The Technical Publishing Company, Limited, 1, Gough-square. [Price 1s. net, 1s. 4d. post free.]

The "Practical Engineer" Electrical Pocket Book and Diary for 1917. (With Buyers' Guide in French, Spanish and Russian.) London: The Technical Publishing Company, Limited, 1, Gough-square. [Price 1s. net, 1s. 4d. post free.]

High Speed Internal Combustion Engines. By ARTHUR W. JUDGE, A.R.C.Sc., Wh.Sc. London and New York: Whittaker and Co.

The Railway Signal and Permanent-Way Engineers' Pocket-Book. London: The Locomotive Publishing Company, Limited, 3, Amen Corner, E.C.; New York: Spon and Chamberlain; Calcutta: *The Indian Railway Gazette*, 11, Kyd-street. [Price 2s. 6d. net.]

Steam Turbines, a Text-Book for Engineering Students. By WILLIAM J. GOUDIE, B.Sc., M.I.Mech.E., Reader in "Theory and Practice of Heat Engines," University of London. London, New York and Calcutta: Longmans, Green and Co. [Price 12s. 6d. net.]

Depreciation and Wasting Assets and their Treatment in Computing Annual Profit and Loss. By P. D. LEAKE, F.I.C.A. London, New York and Melbourne: Sir Isaac Pitman and Sons, Limited. [Price 10s. 6d. net.]

Business Organisation. By H. E. MORGAN. London: Eveleigh Nash, Limited. [Price 5s. net.]

Evaporating, Condensing and Cooling Apparatus. By E. HAUSBRAND. Translated from the second, revised German edition, by A. C. WRIGHT, M.A. (Oxon.), B.Sc. (Lond.). Second English edition, revised. London: Scott, Greenwood and Son. [Price 12s. 6d. net.]

Primary Batteries: Their Theory, Construction and Use. By W. R. COOPER, M.A., B.Sc. New and Enlarged Edition. London: *The Electrician* Printing and Publishing Company, Limited. [Price 12s. 6d. net.]

TECHNICAL EDUCATION, CITY OF MELBOURNE.—With a view to raising the standard of efficiency in the technical branch of the Electric Supply Department's service, the Electric Supply Committee have informed the Council that they have under consideration a proposal to establish (*a*) a system of apprenticeship with provision for technical training; (*b*) a system of scholarships whereby the most promising of the junior engineering staff may be able to gain valuable experience in one or other of the workshops of the best British electrical manufacturers.

THE BRITISH CORPORATION FOR THE REGISTRY OF SHIPPING.

MR. ROBERT CLARK, chairman of the British Corporation, announced at the 27th annual meeting, held recently in Glasgow, that the tonnage on order for registry under the corporation was 440,000 tons, as compared with 240,000 tons last year; but no progress was being made with much of it. Though there was now a greater prospect of the cargo vessels being completed than there had been for some time, there seemed little chance of progress with passenger vessels in the near future. There had been two events of great importance in their own history during the year. The first was the revision of the rules and tables. The completion of this work during a period of stress and difficulty was in itself no small tribute to Mr. Foster King and the staff. The second was the agreement which they had entered into with the reconstructed American Bureau of Shipping. Since last year shipowners had wakened up to what the effect of the Bulkhead Rules was to be on mixed cargo and passenger steamers, and a strong effort was being made to induce the Government to postpone their operation, at any rate until after the war. The war had taught the general public many things, and one of these was that no practicable system of subdivision would make a ship unsinkable. It was a question worthy of the most serious consideration whether the very limited protection which would be given to mixed cargo and passenger vessels by the subdivision required was worth the disadvantages that it would entail. He believed that many owners would give up carrying passengers altogether rather than spoil their steamers for cargo purposes, and this would not be to the advantage of the general community.

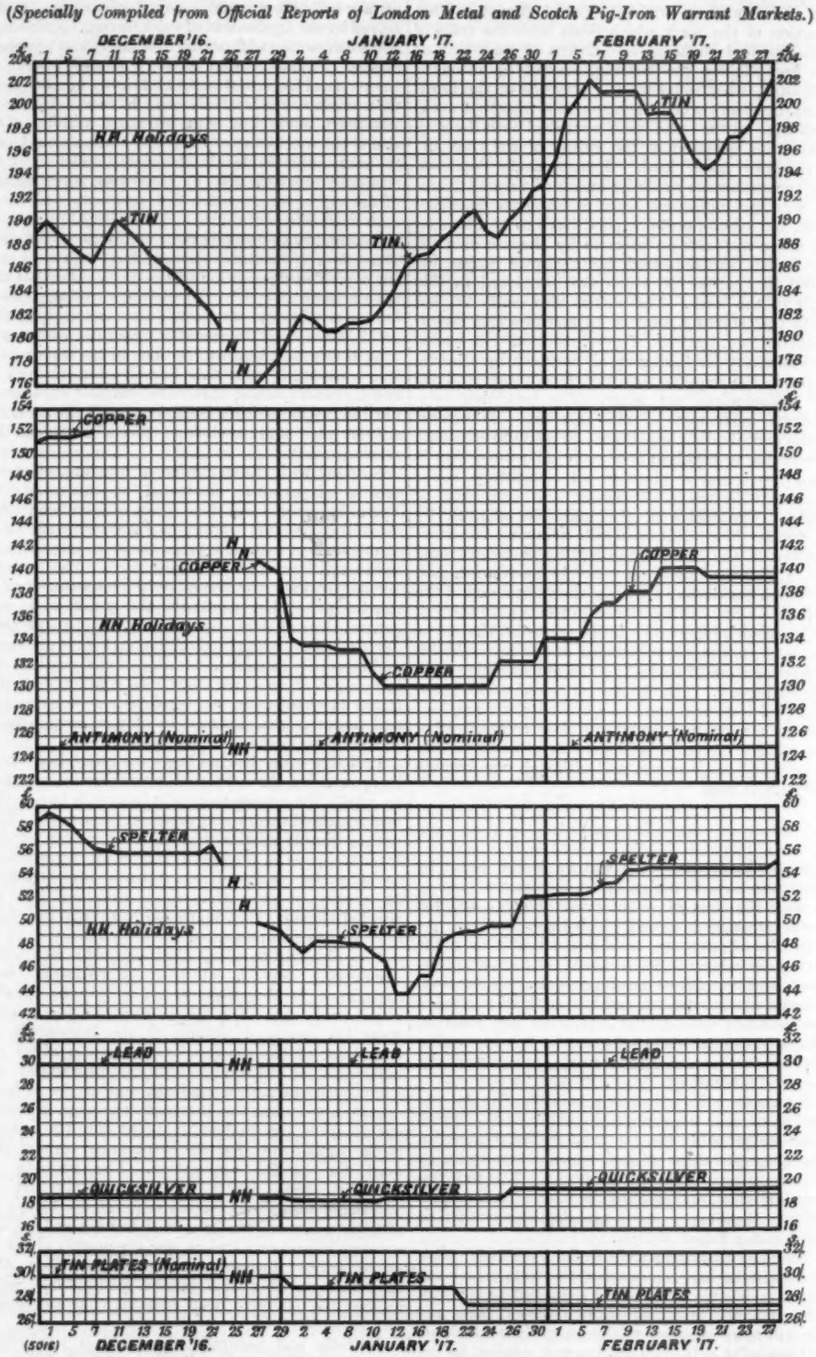
Mr. Fred. J. Stephen, chairman of the Technical Committee, said the committee had never wavered in their belief that the standard stresses and bases of calculation which were adopted in 1891 were not only sound, but were still the best available standards for merchant ship construction. But as the rules embodied only one form of building, and that not the most modern, they felt that the time had come to depart from precedent and to make rules of such scope as would allow the naval architect the greatest possible freedom in designing the kind of structure most suitable to his needs. Formulæ and tables had been prepared, therefore, for all parts of the structure. These took into account the work of each part, eliminated arbitrary restrictions in dimensions, and avoided the waste of material which was necessary as a result of the existing rules, arranged for wide approximations. The revised rules of the society enabled the naval architect to find the scantlings appropriate to his own desires in frame spacing, floor height, depth of knee and number of decks, as well as the particular draught and freeboard for which he wished to design a ship. It was not too much to claim admiration for a system which was so comprehensive as to have seemed almost impossible before it was achieved, and also appreciation for the labour which stood behind the achievement. It was hoped that the elasticity and comprehensiveness of the new system would more than make up for the additional labour now required in compiling a "section." Mr. Foster King, to whom to a very great extent they owed the new rules, was to be heartily congratulated on their production, and the society owed him a deep debt of gratitude.

AN INTERNATIONAL PALACE OF COMMERCE AT AMSTERDAM.—There has been founded at Amsterdam the Dutch limited company "The International Palace of Commerce," which will inaugurate a permanent international exhibition of articles of commerce and industry both from Holland and from abroad, and at the same time create an opportunity for buyers and sellers to meet. The holding of annual fairs is also an item of the programme. The company has been able to secure the whole of the *Paleis voor Volksvlijt* (Palace of National Industry) as soon as, after the conclusion of peace, it may be evacuated by its present temporary occupiers. The company then may dispose of a space of about 5,000 square metres floor space and of about 5,600 square metres of the adjoining garden.

CONTROL OF ALUMINIUM.—The Ministry of Munitions announces that all existing permits for the sale, purchase or remelting of aluminium scrap and swarf are cancelled as from March 1. All dealings in these materials are now governed by the following regulations:—(1) No existing aluminium scrap and swarf may be used for any purpose excepting at the works where the same has been produced and for contracts for which aluminium has been released by the Director of Materials, and as portion of the amount so released. (2) All existing aluminium scrap and swarf not being used at any works where the same has been produced, for contracts for which aluminium has been released by the Director of Materials, and as portion of the amount so released, shall be sold and sent within three weeks from March 1, 1917, to the refiner or one of the refiners, as the case may be, nominated by the Ministry of Munitions for the district where such scrap and swarf is situated. (3) When aluminium scrap and swarf is produced hereafter such scrap and swarf must be used at the works where produced for contracts for which aluminium has been released by the Director of Materials, and as portion of the amount so released, or otherwise sold and sent at or before the end of each month to one or other of the refiners nominated by the Ministry of Munitions for the district where such scrap and swarf is situated. Applications for permits should be made to the Director of Materials, A.M.(2) H., Hotel Victoria, Northumberland-avenue, London, W.C.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



NOTE.—In the diagrams above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for antimony and lead are for English metal in both cases, whilst those for spelter are for American metal. The prices are per ton, but in the case of quicksilver, however, the price is per bottle; the price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7 the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

THE GUIDE TO SOUTH AND EAST AFRICA.—This guide for the current year, which is edited by Mr. A. S. Brown, F.R.M.S., and Mr. G. G. Brown, F.R.G.S., is issued by the Union-Castle Mail Steamship Company, 3 and 4, Fenchurch-street, E.C., at the very low price of 1*s.* The present is the 23rd annual edition, and the publishers announce that it has been entirely rearranged, the subjects dealt with being placed in a new sequence so as to facilitate reference. In making these alterations the requirements of a number of young men now fighting in our armies, who may be expected to choose a life in the Colonies after the termination of the war, have been carefully borne in mind. The book will appeal both to the latter and also to the general public. It gives a vast amount of interesting information and contains a large number of excellent maps and plans.

ALTERNATING STRESS EXPERIMENTS.*

By WILLIAM MASON, D.Sc.,† of the University of Liverpool (Associate Member).

(*Concluded from page* 190.)

Discussion of Results.—References to Tables II, III and IV will show that even at comparatively small ranges of stress there was a small width of hysteresis loop. The order of magnitude of this width, however, indicates elastic hysteresis only‡. The ranges of repeated stress at which elasticity began to be impaired were in the near proximity of ± 5.50 tons per square inch in specimens A 10, B 22, and B 31; and in A 7 about ± 5.75 tons per square inch of shear stress. In alternating bending the ranges of stress were very closely ± 11.0 tons per square inch of direct stress; and thus the range of maximum shear stress was ± 5.50, the same, or very nearly the same, as for the alternating torsion. The agreement in these values suggests that shear stress was the prime cause of elastic failure in both alternating torsion and alternating bending, and that Guest's criterion of elastic failure holds for this steel.

A feature exhibited by all curves of range of strain plotted against cycles endured, such as Figs. 8 to 14, pages 188 and 189 *ante*, is the rapid increase of the cyclic strain at the beginning of application of cycles at a given range of torque or of bending moment (greater than that at which the elasticity remained unimpaired), and the subsequent much smaller rate of increase. In solid specimens, or tubular specimens with thick walls, such a shape of curve would be expected. For the real maximum stress induced by a given torque or bending moment will diminish as the cyclical non-elastic strain increases; just as, in static experiments, the real maximum stress in beams or shafts under a given loading tends to diminish when the elastic limits are passed in the regions of great stress. The "calculated" stresses marked on the graphs and given in the tables are the real stresses only when the steel is perfectly elastic; and must be in excess of the real maximum stresses by an increasing amount as the cyclical non-elastic strain develops.

With thin tubular test-pieces this excess may still be fairly large. Thus in B 27 the maximum stress calculated on the assumption of perfect elasticity is 85.3 T, where T is the torque. Calculated on the assumption that the shear stress is uniform over the area of the tube, the stress is 80.3 T—a difference of 6 per cent. upon the former; thus the real maximum stress of the last million cycles of B 27 may have been only ± 5.75 tons per square inch instead of ± 6.10 as marked "calculated" stress upon the graph of Fig. 10. Moreover, since time is required for equalisation of stress over the area of even one of the thin hollow specimens, it seems possible that the real maximum stresses at 200 per minute may be somewhat greater, on this account, than the real maximum stresses at 2 per minute. If this be so, the observed ranges of strain at 200 will be so much the greater, and the speed effect found herein so much the less than they would be for specimens in direct tension and compression.

The rapid rate of increase of cyclical non-elastic strain when a test is commenced, or when a given stress is increased, is exhibited by Dr. L. Bairstow's curves§ of "cyclical permanent set" plotted against a number of cycles endured for direct stress tests; thus it may be fairly assumed that the similar rapid rise and subsequent smaller rate of increase of range of strain is accentuated to a small extent only for the thin-walled hollow specimens tested in repeated torsion. It may be remarked that there was no evidence at all of buckling in the thin-walled specimens. Specimen A 2, Table II, whose wall-thickness was about twice that of the other hollow torsion test-pieces, required a "calculated" range of stress intermediate between those of the latter and of the solid specimens.

The considerably higher ranges of stress, as calculated on the assumption of uniformly varying stress endured by the solid specimens in torsion (and also in bending), point decisively to the conclusion that the distribution of stress over the section does not correspond with that assumption. It is clear that, as suspected previously,‖ the Wöhler ranges of stress determined by bending or torsion alternating tests of solid specimens, and calculated from the loading on the above assumption, must be something like 15 per cent. too high.

In order to compare the ranges of strain at or near the fracture point, it is perhaps most fair to take the ratio of these ranges to the ranges that may be assumed would have existed at the respective ranges of stress if the strain had remained purely elastic. The latter are calculated (Table V, page 212) from the ranges of strain measured at the small ranges of stress at the commencement of the test, and put in Tables II, III and IV under the heading of "Preliminary Deadweight Test." It will be seen from Table V that this ratio is only fairly constant. The author does not as yet infer that a definite minimum range of strain must be established before fracture will occur. The effect of speed upon range of strain requires further investigation, and further tests with very prolonged repetitions of given ranges of stress and their corresponding ranges of strain are wanted. And although a consideration of the latter parts of the tests of A 2, A 7 and B 27 suggests that a very large number of cycles of about ± ¼ ton per square inch less range of stress than the actual range at fracture would have been required to produce fracture, yet it seems probable they would have broken under a smaller range of stress with a less range of strain. The curves for the tests suggest that the range of stress that will cause fracture in, say, 100 million cycles will be nearer the range that actually broke the specimens than the range that brought departure from the elastic condition.

TABLE II.—ALTERNATING TORSION. HOLLOW SPECIMENS.

No. of Specimen.	Preliminary Deadweight Test. Range of Torque.	Preliminary Deadweight Test. Range of Stress.	Preliminary Deadweight Test. Range of Strain.	Range of "Calculated" Stress.*	No. of Cycles from beginning of Test.	No. of Cycles at Range of Stress.	Measurements Obtained by Deadweight Loading. Range of Strain.	Measurements Obtained by Deadweight Loading. Width of Loop.	Range of Strain at 200 Cycles per Minute.	Range of Stress at which Strain Ceased to be Entirely Elastic.
	lb.-inch.	Tons per sq. inch.		Tons per sq. inch.						Tons per sq. inch.
A 2	±223.0	±6.00	7.50	from ±5.9 to ±6.50	344,000	344,000				
				Rest of 14 months.						
				±6.10	000,000 251,000	251,000	—	—	to 7.98	
				±6.60	251,000 2,280,000	2,029,000	—	—	to 11.30	
				±6.85	2,280,000 2,541,000 2,587,400	307,400 — cracked.	—	—	to 12.95	
A 10	±154.3	±4.75	5.27	±4.75	000,000 253,000	253,000	5.27	0.04		
See Fig. 9 (page 188 *ante*).				±5.00	253,000 528,000	275,000	5.54	0.04		
				±5.25	528,000 761,000	237,000	5.82	0.04	5.89	
				±5.50	761,000 1,019,000	258,000	to 6.16	from 0.04 to 0.08	from 6.23 to 6.28	±5.50
				±5.75	1,019,000 1,178,000	159,000	from 6.43 to 6.66	from 0.08 to 0.26	to 6.65	
				±6.00	1,178,000 1,213,000	35,000	to 7.17	from 0.26 to 0.33	to 7.00	
				±6.50	1,213,000 1,443,000 2,100,000 2,317,000	— 1,104,000 — cracked.	to 11.65	to 3.76	to 9.00 to 9.75	
A 12	±152.0	(±5.4)	6.19	(±5.50)	000,000 18,500	18,500	from 6.19 to 6.73	from 0.07 to 0.33		
				(±6.50)	18,500 84,000 235,000	65,500 — found cracked.	—	—	10.05	
B 22	±154.0	±5.0	5.86	±5.00	000,000 31,600	31,600	5.86	0.03	5.90	±5.50
See Fig. 8 (page 188 *ante*).				±5.25	31,600 43,900	12,300	6.15	0.04	6.15	
				±5.50	43,900 79,600	35,700	from 6.45 to 6.50	from 0.04 to 0.04	to 6.52	
				±5.62	79,600 308,000	229,400	from 6.59 to 7.24	from 0.06 to 0.54	to 6.90	
				±6.25	2,431,000 2,643,000	2,335,000 cracked.	—	—	to 10.72	
B 25	±119.0	±5.0	5.90	±6.05	000,000 350,000 420,000	420,000 cracked.	—	—	9.98	
B 26	±121.0	(±5.00)	5.22	(±6.25)	000,000 28,000 78,000	78,000 cracked.	—	—	10.20	
B 27 See Fig. 10 (page 188 *ante*).	±131.0	±5.00	6.03	±5.35	000,000 1,194,000	1,194,000 —	—	—	to 7.48	
				±5.60	1,194,000 3,478,000	2,284,000 —	(See page 189 *ante*)	Fig. 12,	to 9.06	
				±5.85	3,478,000 4,530,000	1,052,000 —	—	—	to 10.15	
				±6.10	4,530,000 5,567,000	1,037,000 cracked.	—	—	to 11.36	
B 28 See Fig. 15 (page 189 *ante*).	±139.0	±5.00	5.93	±6.00	000,000 248,000	248,000				
				±6.25	248,000 961,000	713,000 cracked.	(See page 189 *ante*.)	Fig. 13,		
B 30 See Fig. 15 (page 189 *ante*).	±169.5	±5.00	5.87	±6.25	000,000 940,000	940,000 cracked.	—	—	to 10.65	

* These stresses are calculated from the range of torque on the assumption that the stress is proportional to the radius in the section of the tube.

Frequency of cycles generally 200 per minute. Machine stopped for observations with deadweight loading.

DIAMETERS OF SPECIMENS.

No. of Specimen.	External.	Internal.	Thickness of Wall. Max.	Min.	Mean.	Remarks.
	Inch.	Inch.	Inch.	Inch.	Inch.	
A 2	0.500	0.377	0.0615	0.0615	0.0615	
A 10	0.5705	0.507	0.0317	0.0317	0.0317	
A 12	0.5725	0.510	0.038	0.025	0.0315	Bore very badly eccentric.
B 22	0.5759	0.5142	0.0308	0.0308	0.0308	
B 25	0.5595	0.510	0.0282	0.0232	0.0247	Bore eccentric
B 26	0.562	0.5095	0.0333	0.0195	0.0263	Bore very badly eccentric.
B 27	0.5615	0.5072	0.0277	0.0273	0.0275	
B 28	0.563	0.5053	0.0296	0.0280	0.0288	Bore slightly eccentric.
B 30	0.5755	0.5053	0.0355	0.0345	0.0350	Bore slightly eccentric.

* Paper read before the Institution of Mechanical Engineers, Friday, February 16, 1917.

† Received Bryan Donkin Fund awards in 1910 and 1913.

‡ See "Elastic Hysteresis of Steel." F. E. Rowett. Proc. Roy. Soc. A., vol. 89.

§ Phil. Trans. A. 210. Page 38.

‖ Brit. Assoc. Report, 913. Report on Alternating Stress. Page 24.

The effect of change of speed upon range of strain, illustrated in Figs. 9, 10 and 11 (page 188 *ante*), has already received some attention from the author.* The information herein contained confirms the statements already made, and appears to justify the following argument. Considering the curve (Fig. 11, page 188 *ante*) for A 28, the large increases of range of strain at 371,267 and at 475,432 cycles, contingent upon the change of speed from 200 to 2 cycles per minute, may be reasonably attributed to the greater opportunity for plastic movement for the longer cycle. The augmented ranges shrink under continuance of the slow cycles; apparently a process of hardening goes on, resulting in a smaller plastic movement. If after the shrinkage, as at 372,935 cycles, the speed is put back to 200 per minute, there is an immediate contraction in the range of strain, due now to shorter time for plastic movement, but the new range is less than it was before the original increase of speed. The reduced range, however, increases quickly at the restored higher speed. Again, supposing a test, as that of B 30, to be begun at 2 cycles per minute, or to have continued for a considerable number of cycles at that speed, a change to 200 per minute gives a contraction of strain; continuance at the latter speed increases the range, and the effect of subsequent changes of frequency of cycle is exactly as described above. On the other hand, a change from a given speed and restoration to this speed after a few moments only gives little or no alteration of the range of strain at this speed. In view of these facts the conclusion seems irresistible that the material, after a considerable number of cycles at a given frequency, does not immediately enter into a cyclic condition suitable to a new frequency; and that the condition of plasticity, or of mobility, is different for different speeds of cycle.

If Professor G. T. Beilby's hypothesis of the formation of "mobile" material upon the gliding interfaces during crystalline slipping and of the tendency to hardening of this material be adopted, the condition of strain at any time during alternate stressing at a given range above the elastic limit may be regarded as the net effect of the opposing processes of production and hardening of the mobile material. As a result, the range of strain would tend towards a value which is not exceeded at that range of stress and frequency of cycle, just as exhibited in the curves of this paper and in those of Bairstow.†

The above conclusion that the condition of plasticity of mild steel under alternations of a given stress range is a function of the speed of cycle is not easy to test directly. If it is correct, then increase of range of stress should give a greater immediate increase of range of strain when the speed of cycle is 200 than when it is 2 per minute. Unfortunately the author was unable to measure these immediate increases. An attempt was made in the case of No. A 10 to obtain some confirmation in the following way At 1,442,600 cycles (Fig. 9 and 9a, page 188 *ante*), after 250,000 cycles at 200 per minute, the machine was stopped and as quickly as possible the same range of stress was applied by deadweights. Just before stopping the machine the range (at 200) was 9.00; the range with the weights was 11.65, and the hysteresis loop for the cycle was very far from being a closed curve. Again, at 1,443,698 cycles, after 690 cycles at 2 per minute, the range with deadweights, taken as soon as possible after stopping, was 10.26, and the hysteresis loop was nearly a closed curve; whereas the range before stopping was 9.00. The range of stress was the same in each case. These results point out to a condition of more mobile plasticity at the higher frequency.

Conclusions.—Mild steel will endure a very large number of repetitions of a range stress—considerably greater than the range at which the extra-elastic strain appears—that induces a considerable range of extra-elastic strain. The range of stress (calculated on the assumption of uniformly varying stress) which induces fracture is greater for solid than for hollow test specimens.

The effect of giving rest to a specimen in which an extra-elastic range of strain has developed is to reduce the range of the strain. The physical effect of the rest appears to be similar to that of hardening after strain, and not to be of the nature of recovery of elasticity.‡ The author has not observed in these experiments (with equal + and − stresses) any real adjustment of elastic limits to range of stress.

There appears to be a marked variation with frequency of repetition of cycle of the physical state of mild steel subjected to repetition of a higher range of stress than that consistent with unimpaired elasticity, the mobility being greater with higher frequency.

For the dead mild steel used in this work the range of the induced maximum shear stress at which the elasticity becomes impaired is sensibly the same in both alternating torsion and alternating bending.

The cost of the machine and apparatus used in the experiments has been defrayed by grants from the Royal Society, the Institution of Mechanical Engineers, and the University of Liverpool. The author is indebted also to Professor W. H. Watkinson for facilities for carrying on the work in the engineering laboratories of the University of Liverpool; and to Mr. C. W. Cook, of Manchester, the builder of the machine used.

APPENDIX.

SPEED EFFECT AND INERTIA OF THE MECHANISM.

As mentioned on page 187 *ante*, the range of torque imposed upon a specimen of sensibly perfect elasticity became very slightly increased, and the measured range of strain also proportionately increased when the speed was put up from 2 to 200 cycles per minute. When cyclic non-elastic strain had appeared the same change of speed caused a decrease of range of strain, and the amount of the decrease became continuously greater with the development of non-elastic strain. The question arose

* Proc. Roy. Soc. A. vol. 92. "On Speed Effect and Recovery."

† Phil. Trans. Roy. Soc. A. 210.

‡ Proc. Roy. Soc. A. 92, page 374. "On Speed Effect and Recovery," by the author.

TABLE III.—ALTERNATING TORSION TESTS. SOLID SPECIMENS.

No. of Specimen.	Preliminary Deadweight Test. Range of Torque.	Range of Stress.	Range of Strain.	Range of "Calculated" Stress.*	No. of Cycles from beginning of Test.	No. of Cycles at Range of Stress.	Measurements Obtained by Deadweight Loading. Range of Strain	Width of Hysteresis Loop.	Range of Strain at 200 Cycles per Minute.	Range of Stress at which Strain Ceased to be Entirely Elastic.
	lb.-inch.	Tons per sq. inch.		Tons per sq. inch.						Tons per sq. inch.
A 1 See Fig. 16 (page 189 *ante*).				±6.25	000,000					
				±6.50	1,131,000	1,131,000				
				±6.75	2,304,000	1,173,000				
				±7.00	3,459,000	1,155,000				
				±7.25	4,009,000	550,000				
				±7.50	4,284,000	275,000				
					4,507,000	223,000 broke.				
A 5				±7.50	000,000					
					2,995	2,995	to 15.8	to 5.1		
						Test discontinued.				
A 7 See Fig. 12 (page 189 *ante*).	±182.0	±5.00	7.01	±5.60	0,000,000					
				±5.85	46,200	46,200	7.71	0.06	7.84	
				±6.10	77,300	31,000	from 8.05 to 8.19	to 0.11	to 8.26	between ±5.60 and ±5.85
				±6.35	115,600	38,300	to 8.63	to 0.23	to 8.82	
				±6.65	483,600	368,000	to 9.82	to 0.95	to 9.56	
				±6.90	2,699,000	2,215,400	to 12.30	to 2.38	to 10.96	
				±7.15	4,680,000	1,981,000	to 14.02	to 3.56	to 12.24	
				±7.40	6,552,700	1,872,700	to 15.82	to 4.79	to 13.55	
				±7.65	8,044,000	1,491,900	to 17.29	to 5.60	to 14.67	
					8,079,900	35,000 cracked.				
B 31	±67.0	±5.00	9.53	±5.00	000,000					
				±5.25	8,400	8,400	9.53	0.02		about ±5.60
				±5.60	10,700	2,300	10.16			
				±5.95	25,400	14,700	to 11.10	to 0.10		
					56,600	31,200	to 12.06	to 0.55		
						Test discontinued.				

NOTE.—Frequency of cycles generally 200 per minute. Machine stopped while observations were made with deadweight loading.

Diameter of specimens:— A 1 0.435 in. | A 5 0.4335 in. | A 7 0.436 in. | B 31 0.3125 in.

* These stresses are calculated on the assumption that the stress over the section varies as the radius.

TABLE V.—COMPARISON OF RANGES OF STRAIN AT OR NEAR THE TIME WHEN SPECIMEN CRACKED.

1. Specimen	2. Test	3. Range of Stress when Specimen Cracked	4. Range of Elastic Strain Corresponding to Range of Strain of Col. 3. = A.	5. Observed Range of Strain at Cracking = B.	6. Ratio $= \frac{B}{A}$	7. Number of Repetitions of Range of Col. 3.	8. Remarks.
A 2 hollow thick wall	Torsion	Tons per sq. inch. ± 6.85	$\frac{7.5 \times 6.85}{6.00} = 8.57$	12.95	1.51	307,000	Number of repetitions at ± 6.60 was 2,230,000
A 10 hollow	Torsion	± 6.50	$\frac{5.54 \times 6.50}{5.00} = 7.20$	9.75	1.355	1,104,000	
B 22 hollow	Torsion	± 6.25	$\frac{5.86 \times 6.25}{5.00} = 7.33$	10.72	1.46	2,235,000	
B 27 hollow	Torsion	± 6.10	$\frac{6.03 \times 6.10}{5.00} = 7.37$	11.36	1.54	1,037,000	
B 30 hollow	Torsion	± 6.25	$\frac{5.87 \times 6.25}{5.00} = 7.33$	10.65	1.45	940,000	
A 7 solid	Torsion	*± 7.40	$\frac{7.40 \times 7.00}{5.00} = 10.36$	14.66	1.42	1,527,000	* The range at which fracture occurred was ± 7.65, but the number of cycles at this range was only 35,000.
A 8 hollow	Bending	±13.00	$\frac{\text{(about) } 7.20 \times 13.00}{12.00} = 7.80$	10.78	1.39	164,000	
A 14 hollow	Bending	±12.75	$\frac{5.36 \times 12.75}{10.0} = 6.83$	9.00	1.32	550,000	
A 16 hollow	Bending	±12.75	$\frac{5.13 \times 12.75}{10.0} = 6.55$	8.30	1.27	416,000	
A 11 solid	Bending	±15.30	$\frac{6.60 \times 14.30}{10.5} = 9.00$	11.97	1.33	301,000	
A 15 solid	Bending	±13.75	$\frac{6.12 \times 13.75}{10.0} = 8.41$	10.40	1.24	270,000 (about)	
B 29 solid	Bending	The ranges of strain at ±14.90 and ±15.60 did not approach a constant value. The ranges of strain were very large (see Table III), and indicate that for large ranges of stress that can be endured for a small number only of cycles, the ranges of strain are very large.					

ALTERNATING STRESS EXPERIMENTS.

TABLE IV.—Alternating Bending Tests. Solid and Hollow Specimens.

No. of Specimen.	Preliminary Deadweight Test. Range of Bending Moment.	Preliminary Deadweight Test. Range of Stress.	Preliminary Deadweight Test. Range of Strain.	Range of "Calculated" Stress.*	No. of Cycles from beginning of Test.	No. of Cycles at Range of Stress.	Measurements Obtained by Deadweight Loading. Range of Strain.	Measurements Obtained by Deadweight Loading. Width of Hysteresis Loop.	Range of Strain at 200 Cycles per Minute.	Range of Stress at which Strain Ceased to be Entirely Elastic.
	lb.-inch.	Tons per sq. inch.		Tons per sq. inch.						Tons per sq. inch.
A 8				±13.00	000,000 164,000	164,000 cracked.	—	—	10.78 at 146,000 cycles.	
A 14	±180.0	±10.0	5.36	±10.0	0,000,000 19,100	19,100	5.36	0.03		
				±11.0	19,100 34,000	15,200	6.00 to 6.10		5.97	Rather less than ±11.0
				±11.5	34,000 54,900	20,600	to 6.32	to 0.16	6.28	
				±12.0	54,900 78,400	23,500	to 6.88	to 0.36	to 6.72	
				±12.5	78,400 413,200	334,800	to 9.00	to 1.88	to 8.04	
				±12.75	908,500 963,000	— 549,800 broke.	9.87	2.46	9.00	
A 16 See Fig. 14 (page 180 *ante*).	±172.5	±10.0	5.13	±10.0	0,000,000 38,000	38,000	5.13	0.03	5.20	
				±11.0	38,000 75,000	37,000	from 5.63 to 5.75	from 0.06 to 0.16	from 5.67 to 5.72	Rather less than ±11.0
				±11.5	75,000 121,800	46,000	from 6.01 to 6.29	from 0.17 to 0.38	to 6.10	
				±12.00	121,800 193,000	71,200	from 6.63 to 6.97	from 0.44 to 0.68	to 6.66	
				±12.50	193,000 543,400	350,400	to 8.21	to 1.52	to 7.80	
				±12.75	843,700 959,640	— 416,240 cracked.	8.96	1.99	8.18	
A 11 See Fig 16 (page 180 *ante*).	±197.0	±10.5	6.60	±10.5	000,000 18,500	18,500	6.60	0.03	6.70	
				±10.75	18,500 64,500	46,000	6.98*			
				±11.00	64,500 208,700	144,200	from*7.22 to 7.35		to 7.12	Rather less than ±11.0
				±11.30	208,700 254,700	46,000			to 7.42	
				±11.55	254,700 341,700	87,000			to 7.81	
				±11.70	341,700 402,600	60,900			to 7.92	
				±11.80	402,600 511,300	108,700			to 8.13	
				±12.05	511,300 620,000	108,700			to 8.40	
				±12.35	620,000 676,000	56,000			to 8.69	
				±12.65	676,000 785,800	109,800			to 9.05	
				±13.00	785,800 892,400	106,600			to 9.55	
				±13.35	892,400 995,800	103,200			to 10.10	
				±13.65	995,800 1,098,400	102,600			to 10.73	
				±14.30	1,194,300 1,400,000	301,600 cracked.	—	—	11.97	

Ranges marked thus * were taken at 2 cycles per minute.

TABLE IV.—Alternating Bending Tests. Solid and Hollow Specimens—*continued*.

No. of Specimen.	Preliminary Deadweight Test. Range of Bending Moment.	Preliminary Deadweight Test. Range of Stress.	Preliminary Deadweight Test. Range of Strain.	Range of "Calculated" Stress.*	No. of Cycles from beginning of Test.	No. of Cycles at Range of Stress	Measurements Obtained by Deadweight Loading. Range of Strain.	Measurements Obtained by Deadweight Loading. Width of Hysteresis Loop.	Range of Strain at 200 Cycles per Minute.	Range of Stress at which Strain ceased to be Entirely Elastic.
	lb.-inch.	Tons per sq. inch.		Tons per sq. inch.			Taken at 2 cycles per minute.			Tons per sq. inch.
A 15 See Fig. 13 (page 180 *ante*).	±177.0	±10.0	6.12	±11.00	000,000 48,000	48,000	from 6.74 to 6.89	from 0.03 to 0.11	to 6.96	Rather less than ±11.0
				±11.54	48,000 130,000	82,000	from 7.13 to 7.33	from 0.10 to 0.21	to 7.30	
				±12.00	130,000 206,000	76,000	from 7.64 to 7.84	from 0.21 to 0.37	to 7.72	
				±12.50	206,000 500,000	294,000	to 8.64	to 0.78	to 8.40	
				±13.00	500,000 807,000	307,000	to 9.61	to 1.27	to 9.20	
				±13.25	807,000 1,053,800	246,800	to 10.25	to 1.63	to 9.64	
				±13.50	1,053,800 1,335,300	—	to 10.75	to 1.92	to 9.94	
				±13.75	1,391,000 1,623,000	— about 270,000 found broken.	—	—	10.33	
B 29	±106.0	±9.20	6.50	± 9.20	000,000 23,500	23,500	6.50			
				± 9.70	23,500 64,700	41,200	6.87			
				±10.15	64,700 88,400	23,700	7.20			
				±10.65	88,400 115,400	27,000	7.57			
				±11.05	115,400 142,400	27,000	from 7.86 to 7.90	—	8.00	About ±11.0
				±11.50	142,400 172,300	29,900	from 8.19 to 8.26	—	to 8.23	
				±11.80	172,300 219,400	47,100	from 8.58 to 8.70	—	to 8.52	
				±12.15	219,400 246,100	26,700	to 9.24	—	to 8.94	
				±12.50	246,100 315,500	69,400	to 9.72	—	to 9.25	
				±13.00	315,500 569,500	254,000	to 11.10	—	to 10.36	
				±13.55	569,500 851,500	282,000	to 12.39	—	to 11.48	
				±14.25	851,500 880,500	29,000	—	—	to 12.12	
				±14.90	880,500 933,300	52,800 Rest of 17 hours.	to 15.30	—	to 13.74	
				±14.90	973,400	40,100	to 16.17	—	to 13.97	
				±15.60	973,400 986,500	13,100	to 17.88	—	to 15.18	

The piece was then given some intermittent runs, in all 50,000 cycles, with long intervening periods of rest. Piece became cracked at 1,020,000 cycles and broke at 1,036,400 cycles, the bending moment being that giving ±15.60 tons per square inch "calculated" stress.

* These stresses are calculated on the assumption that the distribution of stress is similar to that when the elasticity is perfect. Frequency of cycles generally 200 per minute. Machine stopped for observations with deadweight loading.

whether this effect of speed was in any way a characteristic of the machne merely.

That it is not a result of increase of amplitude of angular twist, giving in some way lift of the springs S (Figs. 2 and 4, page 187 *ante*) without imposing the full torque, was shown by the behaviour of specimen B 31 of the small diameter 0.3125 in. This was given a large amplitude of elastic twist, with the result that there was the percentage increase of the amplitude of about 1 per cent. usual with increase of speed from 2 to 200 per minute. The speed effect cannot be attributed to vibration of the mirror apparatus, or of the specimen. If these vibrated appreciably at the higher speeds the method of measuring the cyclic strains would not have been possible. There remains the question whether this effect could arise as a consequence of any change of motion of the lever J, due to the character of the forces imposed upon it by the specimen when fatigued.

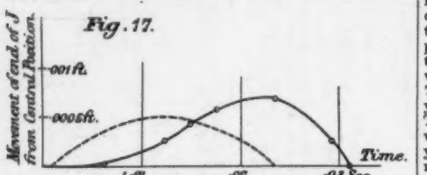
The motion of the end of the lever J against the resistance of the spring S is, when the speed of the machine is very slow, represented by the dotted curve of Fig. 17, page 214, which is very nearly an arc of a sine curve; and in which the abscissæ are time and the ordinates the amount of the departure of the end of J from its position of rest. The maximum departure—represented by the maximum

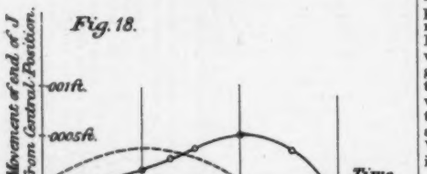
Diameters of Specimens.

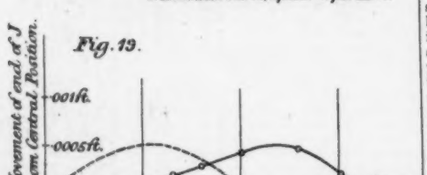
No. of Specimen.	External Diameter.	Internal Diameter.	Thickness of Wall.
	Inch.	Inch.	Inch.
A 8	0.4375	0.3815	0.0280
A 14	0.5003	0.3835	0.0584
A 16	0.5765	0.506	0.0357
A 11	0.436 solid	—	—
A 15	0.432 solid	—	—
B 29	0.3747 solid	—	—

ordinate of the dotted curve—of course depends on the amplitude of the motion given by the mechanism to the torque lever H (Fig. 5, page 187 *ante*), on the stiffness of the springs S and on the torsional rigidity of the specimen. As stated on page 187 *ante* this maximum departure did not exceed $\frac{1}{1000}$ in. during the tests recorded in the paper.

Taking specimen B. 27 as an example, the range of torque was ± 11.6 ft.-lb. with a range of strain of 6.58 cm. on the scale, and a lift of J (that is, of the springs S) on either side of 0.0005 ft., the elasticity being sensibly perfect and the speed very slow. A rather tedious calculation shows that with nothing altered except the speed, the inertia of J will cause the range of torque to become ± 11.8 ft.-lb. at 200 cycles per minute, and the lift of J to become 0.0007 ft. The curve of departure (or lift) of J is now the full-line curve of Fig. 17; but since, in working, the lift is kept as nearly as possible the same amount, the state of affairs is represented by Fig. 18, in which the lift of J is the same as before (that is 0.0005 ft.), and the range of torque is shown by the







calculation to be ± 11.75 ft.-lb. Thus the increase of torque is by calculation 0.15 ft.-lb. or 1.3 per cent. when the speed is put up from 2 to 200 per minute and the lift is kept the same; or with a lift of 0.005 in. at both speeds the increase is 1.1 per cent. Measurements of the increase of range of strain with this change of speed showed agreement between this percentage increase of strain and the percentage increase of torque given by the calculation.

When the material has developed non-elastic strain, then, as regards the effect of the inertia of J, the altered rigidity of the specimen must be considered. Assuming for the purpose of calculation that the rigidity is diminished, during increase of torque in the cycle, by 50 per cent., the curve of lift of J is now that of Fig. 19, and the percentage increase of torque for a speed of 200 per minute is 0.75. This figure, of course, depends on the above estimate of loss of rigidity; but the important point is that calculation gives still an increase and not a decrease of range of torque when the springs S lift the same amount at the higher as at a very low speed.

Direct evidence that the speed effect is only remotely, if at all, connected with any mere machine effect is afforded by the rate of decrease of strain with increase of speed and *vice versa*. The parts of the graph of Fig. 11 (page 188 *ante*) between 411,580 and 413,955 cycles, and between 416,600 and 419,300 cycles, which are typical of several such curves for different specimens, show that the alteration of range of strain with speed in a "fatigued" specimen is greatest at the lowest speeds, the latter being so slow that no machine or inertia effect could be of importance.

ON THE TEACHING OF BUILDING.—The Board of Education has issued a memorandum, No. 978, which has been drawn up with the object of providing suggestions for teachers of building subjects in evening technical schools. It is published at the price of 6*d.* net by H.M. Stationery Office.

FOREIGN ENGINEERING PROJECTS.

WE give below a few data on foreign engineering projects taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Italy.—H.M. Embassy at Rome reports, under date February 3, an announcement to the effect that the Italian Government have granted to the Società per la Forze Idrauliche della Silla a concession for the construction and working of water-power reservoirs in the upper valleys of the rivers Neto, Arno, and Ampollino. The concession includes the construction of all channels required for the passage of the water, as well as all other works connected with the production therefrom of electric current. The irrigation of the lower valley of the river Neto is also included in the proposed scheme. The concession is for 60 years, at the end of which period the company must hand over to the State the reservoirs, electrical power works, and irrigation works. Apart from the industrial uses to which power produced by the company will be put, the company is under a contract to supply, within a year from the opening of the first power works, the electric current required for working the Calabro-Lucanno Railway. The total cost of the works to be established is estimated to amount to 70,000,000 lire, and they must be completed within 15 years from the date of the concession (October 6, 1916). The company is required to construct two reservoirs, with electrical works producing 20,000 h.p., within five years of obtaining the concession. 25 lire = 1*l.* (at par rate).

SOCIETY OF GLASS TECHNOLOGY.

THE February meeting of the above society was held in the University of Sheffield on the 15th ult. at 4.30 p.m. Previous to the meeting several series of glasses made from British sands were exhibited by Mr. C. J. Peddle, M.Sc., F.C.S. The effect of washing and grading was amply illustrated, and the fact that good colourless glass can be made from certain British sands after proper treatment was well brought out. Alongside the glasses were specimens of the various sands before and after treatment. The value of the exhibit was enhanced by a splendid set of micro-photographs, the work of Mr. Wilfred R. Barker, showing the grading of sands and illustrating the value of washing.

The president (Mr. W. F. J. Wood, B.Sc.) took the chair, and the proceedings opened with a paper by Mr. F. Twyman, of London, on "The Annealing of Glass."

The author pointed out that want of annealing in glass leading to fracture was due to the presence of internal stress. Glass behaves at all temperatures as a viscous liquid and exhibits a continuous and gradual variation in viscosity from almost zero at high temperatures to almost infinity at 0 deg. C. In molten glass there is no permanent internal stress, whilst at ordinary temperatures glass is almost perfectly elastic, so that stress cannot originate at either high or low temperatures. At high temperatures internal stresses, if any, die away very quickly, but between this high temperature and the low temperature where glass acts as an elastic solid there is a region where internal stress may take several minutes or even hours to die away. It is this region of temperature which is important in annealing, and care must be exercised in cooling a glass object through its "annealing range" in order to free it from internal stress.

The author described the method employed to determine the annealing temperature of various glasses, and then showed that the mobility (*i.e.*, inverse viscosity) of glass doubled for each 8 deg. C. rise in temperature. For temperatures near the annealing temperature of glass the following formula has been proved correct.

$$M = k \times 2^{\left(\frac{\theta}{8}\right)}$$

where M is the mobility, k is a constant, and θ the temperature in deg C.

Results were given showing the rapid rise of mobility with rise of temperature. Thus a certain glass kept at 420 deg. C. required a period of 83 hours for internal stress to disappear, whilst at 580 deg. C. the same glass was freed from stress in 0.3 seconds. The actual annealing temperature, *i.e.*, the temperature at which stress easily disappears and yet low enough not to cause deformation of the object, differs widely for various glasses. It is a matter of vital importance to the manufacturer to know the annealing temperature of his glass. For example, suppose the annealing temperature of a glass is 500 deg. C., *i.e.*, stress will almost disappear from the glass at this temperature in about 3 minutes, then if the glass is held at 420 deg. C. it would require 45 hours to anneal, whilst if kept at 580 deg. C. it would probably go out of shape.

Considerable discussion ensued, the relative value of long and short lehrs, and the possibility of annealing different glasses at the same time being touched upon in particular.

Mr. S. English, M.Sc., of the Department of Glass Technology, Sheffield University, then read a paper on "Annealing."

The demand from manufacturers as to improvements in processes of annealing, coupled with anomalous results obtained for the coefficient of thermal expansion of glass which was known to be strained, had led to an investigation on annealing. In the first place some knowledge of the rate of annealing at various temperatures was sought, and with this end in view small glass rods were heated at the required temperatures in an electric furnace, observations being carried out by means of a special apparatus built of up two Nicol prisms and a system of lenses. The well-known rings and cross, as seen in a uniaxial crystal, were always observed in the rod under experiment, and as the experiment proceeded the rings expanded and passed from the circle of light, the rate at which they disappeared being a measure of the rate of annealing at that temperature. Several lantern slides were shown illustrating the appearance of the rod as annealing proceeded, and results were given for several glasses. For example the times necessary for the last four rings to disappear in the case of a chemical resistant glass were for various temperatures as follows:—

Temperature. Deg. C.	Time Minutes.
500	1,230
550	50
600	20
625	12

The times required for the field of view in the apparatus to become perfectly dark, *i.e.*, until all stress had disappeared, were:—

Temperature. Deg. C.	Time. Minutes.
550	570
600	270
625	18
650	10

Since the annealing of glass is the relieving due to incipient softening of internal strains the temperature at which annealing proceeds at a fairly rapid rate may be obtained by finding the temperature at which glass will yield to external forces. The apparatus for carrying out this work was described and curves were given showing results with actual glasses. The optical and mechanical methods of determining annealing temperatures as described by the author yield results in close agreement, and prove that the annealing temperature of glass is considerably below the temperature of actual softening.

The next meeting of the society will be held in Birmingham on Thursday, March 15, at 2 p.m., when papers will be read on the question of the construction of glass furnaces.

CATALOGUES.

Friction Clutches.—The Carlyle Johnson Machine Company, of Manchester, Conn., U.S.A., have sent us a booklet illustrating a number of applications of their friction clutch, from which it appears that the device is specially applicable to the operation of gear changing on machine tools and similar work where a positive action under not too great a load is required.

Gas Furnace Burners.—The Power Gas Economy Company of 50, Wellington-street, Glasgow, make a speciality of apparatus for burning gas for such purposes as steam raising, and have sent us a leaflet illustrating some typical installations which they have carried out. These include boilers fired with blast-furnace or coke-oven gas and some fired partially by gas and partially by coal.

Suction Cleaners.—Two types of "suction cleaners," or portable vacuum cleaners, are illustrated in pamphlet just published by the Electric Suction Cleaner Company of 56, Victoria-street, London, S.W. One is of the form, now quite familiar, in which the suction fan and dust-bag are handled much in the same manner as an ordinary broom. The other is arranged to clip on to a waist-belt, and thus leaves both hands free to manipulate the nozzle, which is fixed on the end of a length of flexible hose.

Blue-Print Machines.—The C. F. Pease Company, of 213, Institute-place, Chicago, Ill., U.S.A., have evolved a machine for taking blue prints from tracings, washing and drying the prints automatically, and delivering both prints and tracings into convenient receptacles. All these operations are carried on continuously, and some 150 24 in. by 36 in. prints can be turned out per hour. Electricity is used to drive the machine and provide the illuminant, while either gas or electricity is used for drying.

Hardening Screw Gauges.—A leaflet recently issued by the Westminster Electrical Testing Laboratory, of York-mansions, York-street, Westminster, S.W., gives some extracts from the report of the Hardness Tests Research Committee, which go to show that the Wild-Barfield process of hardening steel gives a greater resistance to abrasion than any other system. At the same time the process does not have any distorting effect on delicate pieces, such as screw gauges, &c., neither does it produce any scale.

Steam Engines of All Kinds.—A neat little catalogue recently issued by Messrs. Robey and Co., Limited, of Lincoln, gives some idea of the wide variety of engines manufactured by this firm. It comprises some 50 pages, and on each is illustrated—and described in brief—a different type. They include portable, semi-portable, and undertype steam engines, high-speed vertical engines, medium-stroke, horizontal and vertical engines, boilers, pumps, traction engines, road rollers, steam wagons, and semi-Diesel crude oil engines.

Grabs.—A new type of grab, for handling coal, is advocated in a pamphlet recently issued by Messrs. Fraser and Chalmers, of Erith, Kent. It is evidently of very substantial and simple design, but yet effective, in that it will always fill itself even when lowered gently on to the coal it is to lift, while it is claimed that it causes less breakage than any other type of grab and will not damage the bottom of barges from which it is used to unload. It is said that coal stacked by these grabs may safely be piled 12 ft. higher than is usually considered the maximum height without fear of its overheating.